Michigan State University
AgBioResearch

In Cooperation With
Michigan Potato Industry Commission

Michigan Potato Research Report
Volume 44

2012

MICHIGAN POTATOES
MICHIGAN POTATO INDUSTRY COMMISSION

Michigan Potato Industry Commission

13109 Schavey Rd., Ste. 7   DeWitt, MI 48820   517.669.8377   Fax 517.669.8377
www.mipotato.com   email: info@mipotato.com

April 2013

To All Michigan Potato Growers & Shippers:

The Michigan Potato Industry Commission, Michigan State University's AgBioReseach Station and Cooperative Extension Service are pleased to provide you with a copy of the results from the 2012 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 2013 season.

Table of Contents

2012 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2012 Potato Research Report contains reports of the many potato research projects conducted by Michigan State University (MSU) potato researchers at several locations. The 2012 report is the 44th 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 Center (MRC) and the many details which are a part of its operation. We also want to recognize Barb Smith at MPIC and Luke Steere, MSU for helping with the details of this final draft.

WEATHER

The overall 6-month average maximum temperature during the 2012 growing season was five degrees higher than the 6-month average maximum temperature for the 2011 season and was four degrees higher than the 15-year average (Table 1). The 6-month average minimum temperature for 2012 was one degree lower than the 15-year average. There were 15 days with recorded temperature readings of 90 °F or above in 2012. There were 143 hours of 70 °F temperatures between the hours of 10 PM and 8 AM which occurred over 30 different days, April to September (Data not shown). There were no days in May that the minimum air temperature was below 32 °F. The average maximum temperature for July 2012 was eight degrees higher than the 15-year average (Table 1). In October 2012, during the period from the 1st to the 20th there were seven days with no measureable rainfall. For the period from September 15th to October 20th, there were eight days that the minimum air temperature was below 32 °F.

Rainfall for April through September was 12.02 inches, which was 6.6 inches below the 15-year average (Table 2). In October 2012, 4.85 inches of rain was recorded. Irrigation at MRC was applied 13 times from May 24th to September 24th, averaging 0.77 inches for each application. The total amount of irrigation water applied during this time period was 9.95 inches.

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

Year	April		May		June		July		August		September		6-Month Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1998	60	37	75	51	77	56	82	58	81	60	76	52	75	52
1999	59	37	71	48	77	55	84	62	76	56	73	48	73	51
2000	56	34	70	49	75	57	77	56	79	57	70	49	71	50
2001	61	37	70	49	78	57	83	58	72	70	69	48	72	53
2002	56	36	63	42	79	58	85	62	81	58	77	52	73	51
2003	56	33	64	44	77	52	81	58	82	58	72	48	72	49
2004	62	37	67	46	74	54	79	57	76	53	78	49	73	49
2005	62	36	65	41	82	60	82	58	81	58	77	51	75	51
2006	62	36	61	46	78	54	83	61	80	58	68	48	72	51
2007	53	33	73	47	82	54	81	56	80	58	76	50	74	50
2008	61	37	67	40	77	56	80	58	80	54	73	50	73	49
2009	56	34	67	45	76	54	75	53	76	56	74	49	71	49
2010	64	38	70	49	77	57	83	62	82	61	69	50	74	53
2011	53	34	68	48	77	56	85	62	79	58	70	48	72	51
2012	**58**	**34**	**73**	**48**	**84**	**53**	**90**	**62**	**82**	**55**	**74**	**46**	**77**	**50**
15-Year Average	59	35	68	46	78	56	82	59	79	58	73	49	73	51

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

Year	April	May	June	July	August	September	Total
1998	2.40	2.21	1.82	0.40	2.22	3.05	12.10
1999	5.49	5.07	5.82	4.29	5.46	4.03	30.16
2000	3.18	6.46	4.50	3.79	5.28	5.25	28.46
2001	3.28	6.74	2.90	2.49	5.71	4.43	25.55
2002	2.88	4.16	3.28	3.62	7.12	1.59	22.65
2003	0.70	3.44	1.85	2.60	2.60	2.06	13.25
2004	1.79	8.18	3.13	1.72	1.99	0.32	17.13
2005	0.69	1.39	3.57	3.65	1.85	3.90	15.05
2006	2.73	4.45	2.18	5.55	2.25	3.15	20.31
2007	2.64	1.60	1.58	2.43	2.34	1.18	11.77
2008	1.59	1.69	2.95	3.07	3.03	5.03	17.36
2009	3.94	2.15	2.43	2.07	4.74	1.49	16.82
2010	1.59	3.68	3.21	2.14	2.63	1.88	15.13
2011	3.42	3.08	2.38	1.63	2.57	1.84	14.92
2012	**2.35**	**0.98**	**0.99**	**3.63**	**3.31**	**0.76**	**12.02**
15-Year Average	2.58	3.69	2.84	2.87	3.54	2.66	18.18

GROWING DEGREE DAYS

Tables 3 and 4 summarize the cumulative growing degree days (GDD) for 2012. Growing degree days base 50 for May through September, 2012, are in (Table 3) and growing degree days base 40 for May through September, 2012, are in (Table 4). The total GDD base 50 for 2012 was 2415 (Table 3), which is higher than the 10-year average. The total GDD base 40 for 2012 was 3762, remaining slightly above the seven year average for the same recorded period May through September 2006-2012 (Table 4).

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

	Cumulative Monthly Totals				
Year	May	June	July	August	September
2003	330	762	1302	1922	2256
2004	245	662	1200	1639	2060
2005	195	826	1449	2035	2458
2006	283	765	1444	2016	2271
2007	358	926	1494	2084	2495
2008	205	700	1298	1816	2152
2009	247	700	1133	1622	1963
2010	352	857	1561	2231	2531
2011	299	788	1512	2085	2393
2012	**371**	**702**	**1495**	**2062**	**2415**
10-Year Average	289	769	1389	1951	2299

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

	Cumulative Monthly Totals				
Year	May	June	July	August	September
2006	532	1310	2298	3180	3707
2007	639	1503	2379	3277	3966
2008	447	1240	2147	2973	3596
2009	519	1264	2004	2800	3420
2010	610	1411	2424	3402	3979
2011	567	1354	2388	3270	3848
2012	**652**	**1177**	**2280**	**3153**	**3762**
2013					
2014					
2015					
10-Year Average	567	1323	2274	3151	3754

*2003-2012 data from the weather station at MSU Montcalm Research Center "Enviro-weather", Michigan Weather Station Network, Entrican, MI.

PREVIOUS CROPS, SOIL TESTS AND FERTILIZERS

The general potato research area utilized in 2012 was rented from Steve Comden, directly to the West of the Montcalm Research Center. This acreage was planted to a field corn crop in the spring of 2011 and harvested fall 2011 with crop residue disked into the soil. In the spring of 2012, the recommended rate of potash was applied, in addition to, 2 tons/A of dried chicken litter. These products were disked into the remaining corn residue. The chicken litter nutrient analysis was 4-3-2-8%Ca with a carbon to nitrogen ratio of 6.9:1. The ground was deep chiseled, field cultivated and direct planted to potatoes. The area was not fumigated with Vapam prior to potato planting, but Vydate C-LV was applied in-furrow at planting. Early potato vine senescence was not an issue in 2012.

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

	lbs/A			
pH	P_2O_5	K_2O	Ca	Mg
5.8	344 (172 ppm)	160 (80 ppm)	708 (354 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-Mg)
Broadcast at plow down	0-0-21-10	280 lbs/A	0-0-59-28
	10%B	6 lbs/A	0.6 lb. B
At planting	28-0-0	26 gpa	78-0-0
	10-34-0	6 gpa	7-25-0
At cultivation	28-0-0	25 gpa	75-0-0
At hilling	46-0-0	150 lbs/A	69-0-0
Late side dress (late varieties)	46-0-0	150 lbs/A	69-0-0

Calcium and Nitrogen were applied July 9th in the form of liquid Calcium Nitrate (with an analysis of 30% Ca and 25% N) for a total application of 7 gpa. The composite nutrient value resulted in 25 lbs actual Ca and 21 lbs of N being applied per acre on the potato production area.

HERBICIDES AND PEST CONTROL

A pre-emergence application of Linex at 1.5 quarts/A and Dual II at 1.33 pints/A was made in late May. A post-emergence application of Matrix at 1.3 oz/A was made in late July.

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

Fungicides used were; Bravo, Tanos, Echo and Manzate over 12 applications.
Potato vines were desiccated with Reglone in early September at a rate of 2 pints/A.

2012 POTATO BREEDING AND GENETICS RESEARCH REPORT

David S. Douches, J. Coombs, K. Zarka, G. Steere, M. Zuelke, D. Zarka, K. Felcher and D. Kells

Department of Plant, Soil and Microbial Sciences
Michigan State University
East Lansing, MI 48824

Cooperators: Zsofia Szendrei, Willie Kirk, Jay Hao and Chris Long

INTRODUCTION

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

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

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

PROCEDURE

I. Varietal Development

Breeding, Selection and Variety Evaluation:

The MSU breeding program has been operating for over 20 years and we feel that we have advanced the germplasm so that we can breed scab and late blight resistant varieties for Michigan. We have the genetic variation to combine tuber shape, skin type, scab resistance and low sugars, yield and storability as well as late blight, PVY and golden nematode resistances. Secondly, we have been improved the efficiency of the breeding cycle by defining more precisely the commercial needs of the new varieties and make better decisions more quickly in the first three years of the breeding program cycle. Third, we have raised our standards for what we consider a commercial selection for testing. Fourth, we have been able to increase our efficiency because we are conducting an integrated selection based upon our disease nurseries, post-harvest evaluations for specific gravity and chip quality and DNA tests. Furthermore, we have also revised the selection scheme so that we have reduced a year from the early generation cycle. The MSU Breeding program continues to test MSU-bred lines in replicated trials (over 160 lines) and on grower farms (15 lines). We also annually enter 3-4 lines in the North Central regional trials, 2-4 lines in the USPB/SFA trials and send many of the advanced breeding lines to other states, Canada and various international sites for testing. The NCBT in 2012 allowed us to test the over 50 MSU lines at 11 locations around the country. Through a cooperative effort of MPIC, commercial growers, seed growers, Chris Long, the MSU breeding program and the processors, we are working together to help move the best lines towards larger scale commercial testing and have chip-processing lines evaluated in the Commercial Demonstration Storage facility (500 cwt bins). At this time, we have many advanced selections that have chipping qualities along with scab or late blight resistance, bruise resistance, etc. with commercial potential. Six of these are in the fast track commercial seed production (MSL007-B, MSJ126-9Y, MSH228-6, MSL292-A, MSR061-1 and MSK061-4). MSL292-A and MSJ126-9Y can store at temperatures below 50F and maintain low sugars until June.

In 2013 the MSU breeding program will cross elite germplasm to generate and evaluate 60,000 new seedlings for adaptation to Michigan. In the subsequent years these selections are then advanced to 12-hill (year 2), 30-hill (year 3), 50-hill, and 100-hill plots, with increasing selection pressure for agronomic, quality and disease and/or insect resistance parameters. We now have in place field sites for early generation selection for late blight, scab and Colorado potato beetle resistant lines. Early generation evaluation of these key traits increases our effectiveness in identifying commercially valuable advanced selections. From this 3-year early generation evaluation and selection phase of the breeding program we generate over 100 MSU-bred advanced selections that are then to be tested and evaluated under more intensive replicated trials at the Montcalm Research Center. We are also producing the FG1 and FG2 level seed of the most promising selections from the MSU breeding program for in-state grower-cooperator trials, out-of-state trials, North Central Regional trials, national USPB/SFA trials and MSU research farm trials.

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

Currently, the breeding program has in tissue culture about 1000 clones in the MSU bank and 80 new candidates that are in process for transfer to tissue culture. We want to continue to work closely with the commercial growers and seed industry to test and provide seed for more intensive evaluation. Through this linkage we hope to identify the breeding selections that have merit to achieve varietal status in Michigan.

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

Evaluation of Advanced Selections for Extended Storage

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

II. Germplasm Enhancement

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

III. Integration of Genetic Engineering with Potato Breeding

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

RESULTS AND DISCUSSION

I. Varietal Development

Breeding

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

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

Chip-Processing

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

Tablestock

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

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

Early harvest breeding material screen

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

Disease and Insect Resistance Breeding

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

Table 1 Early Observation Trial: Most promising lines.

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

[1]Merit Rating: 1-Great, 2-Keep, 3-Marginal, 4-Drop
Planted 5/9/12; Harvested 8/6/12. 89 DAP. 10-hill plots planted in 10 ft plots.

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

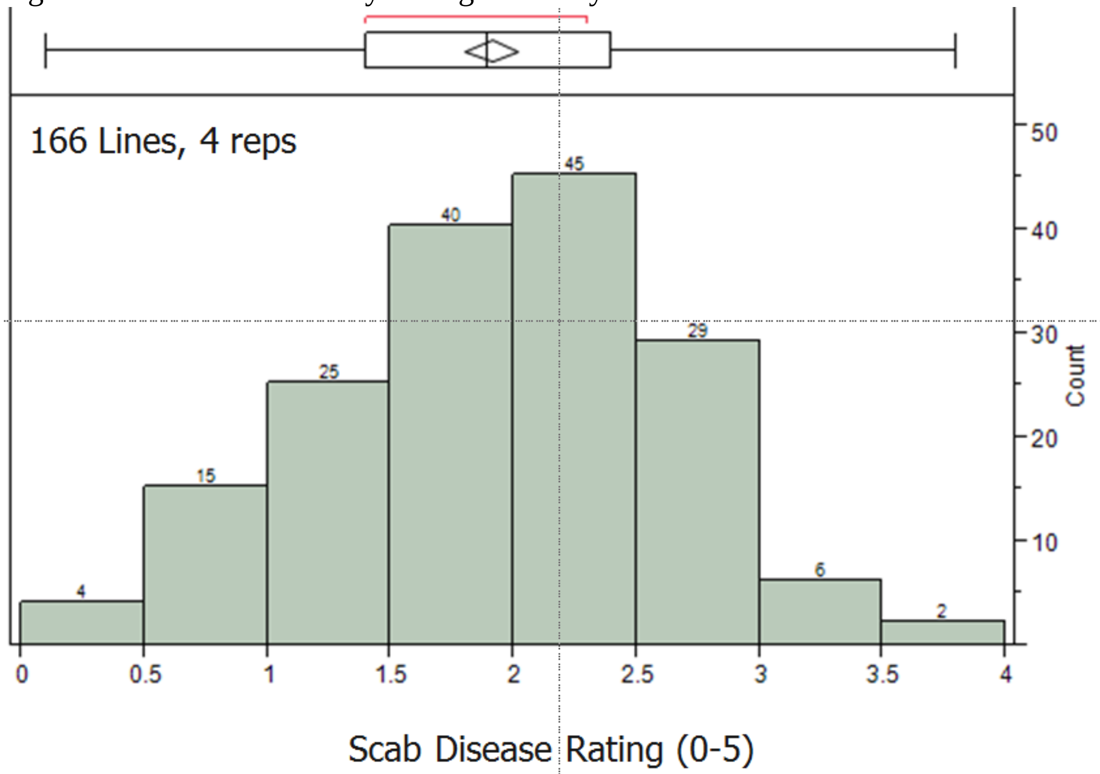
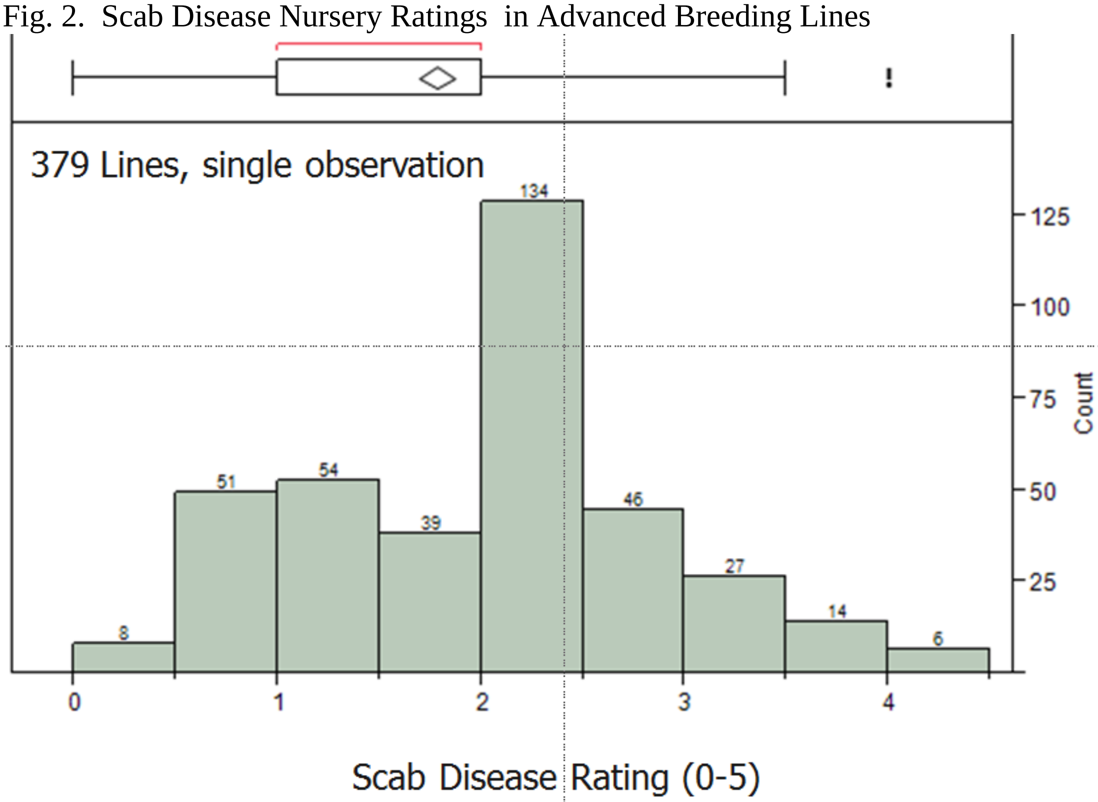


Fig. 2. Scab Disease Nursery Ratings in Advanced Breeding Lines



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

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

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

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

HSD=1.18

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

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

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

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

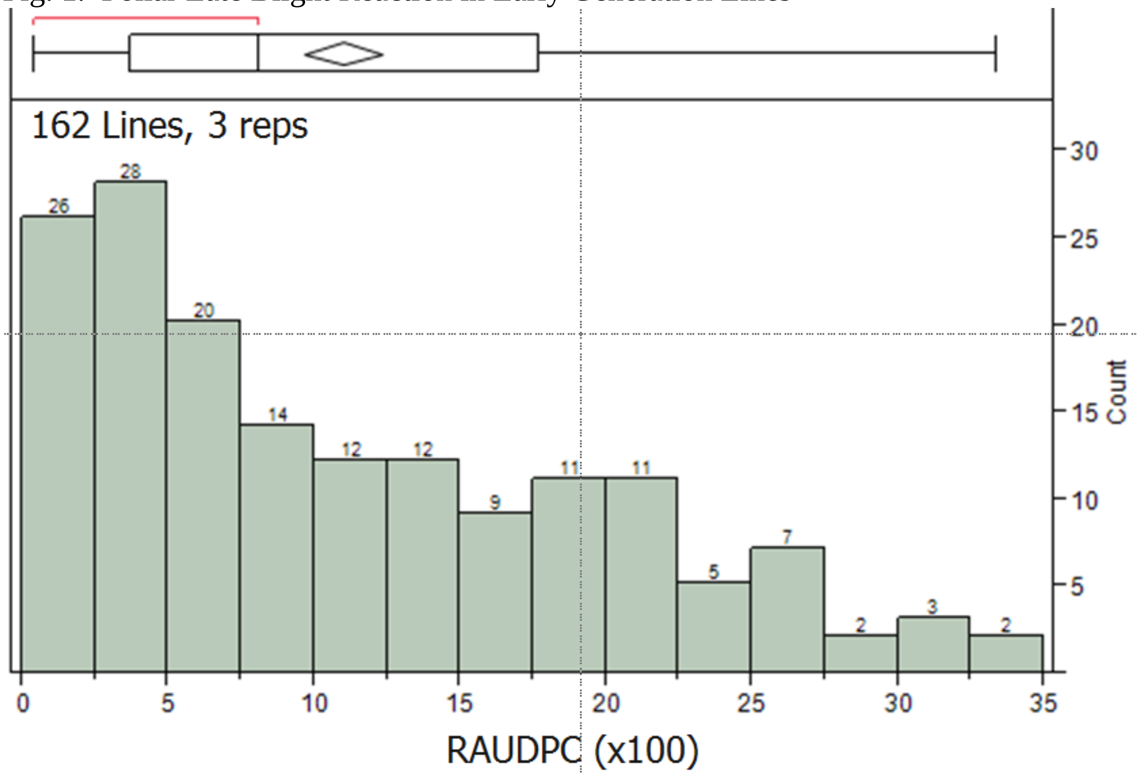


Fig. 2. Foliar Late Blight Reaction in Advanced Breeding Lines

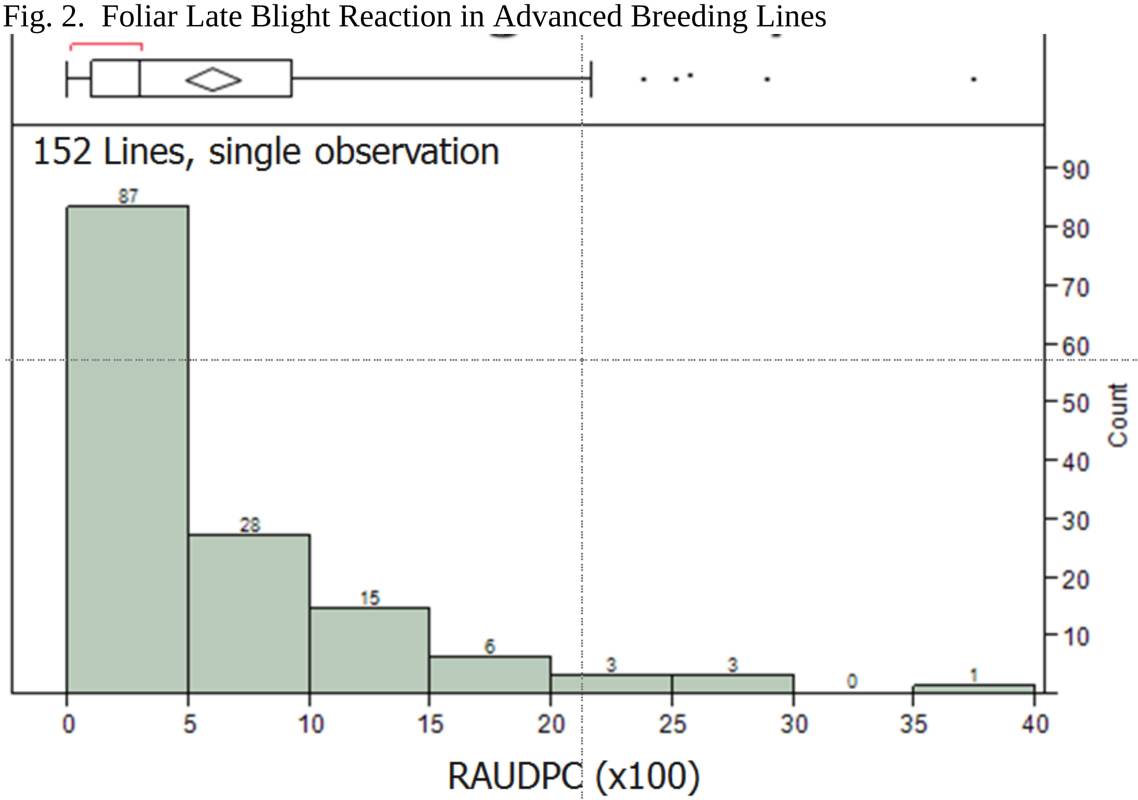
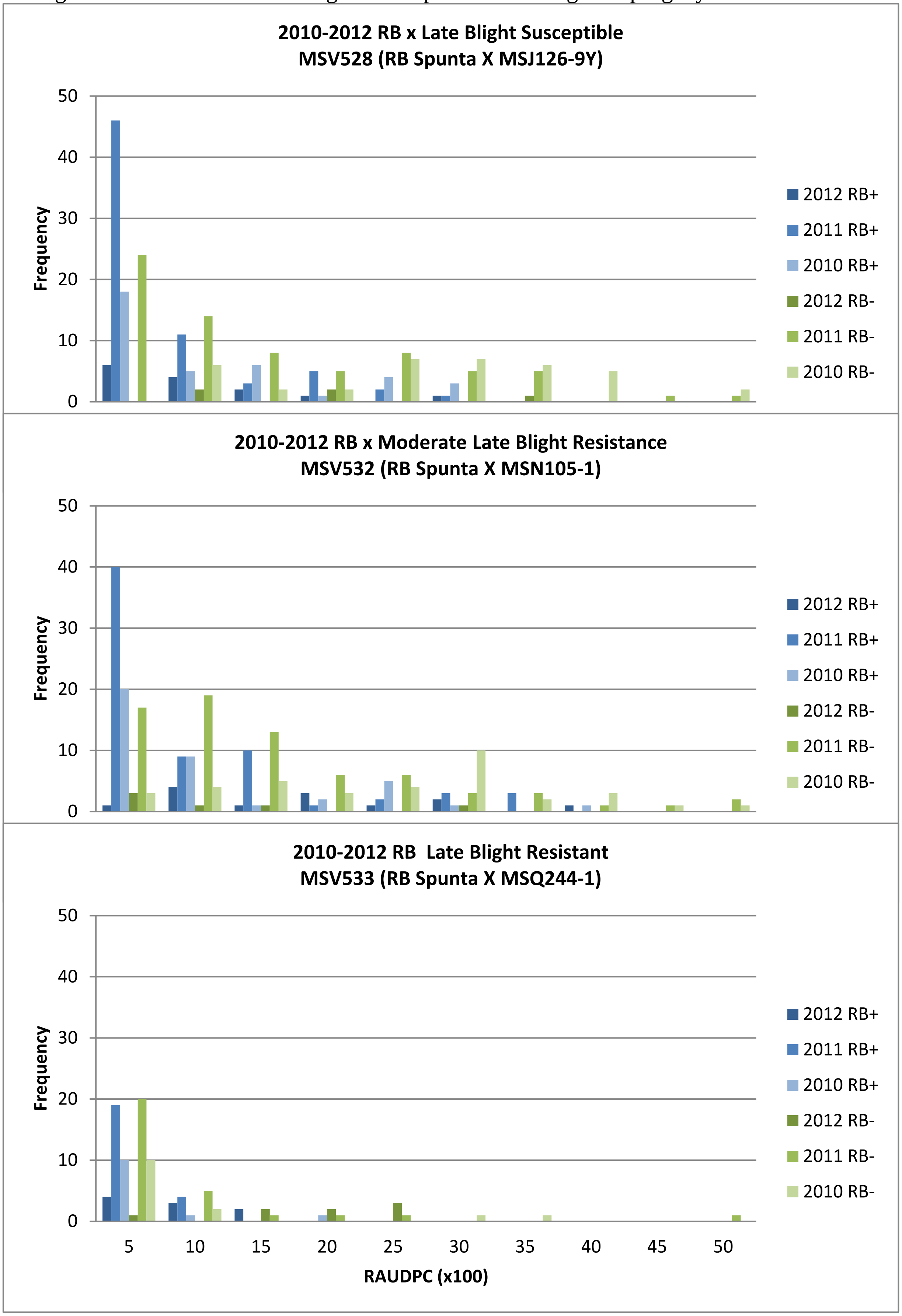


Fig. 3. Distribution for late blight in RB positive and negative progeny



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

.

Russet Table Varieties for Michigan

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

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

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

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

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

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

National Coordinated Breeder Trial (NCBT)

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

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

Variety Release

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

MSU Lines with Commercial Tracking:

MSJ126-9Y (Posen)

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

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

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

MSH228-6

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

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

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

MSL292-A (Manistee)

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

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

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

MSL007-B

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

Strengths: MSL007-B is a chip-processing potato with an attractive, uniform round appearance with shallow eyes. This variety has resistance to *Streptomyces scabies* (common scab) stronger than Pike, with a strong, netted skin. MSL007-B was the most highly merit rated line in the National Chip Processing Trial across eight locations in 2010.

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

MSR061-1

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

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

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

MSR127-2

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

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

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

II. Germplasm Enhancement

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

III. Integration of Genetic Engineering with Potato Breeding

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

Funding: Fed. Grant/MPIC

2012 POTATO VARIETY EVALUATIONS

D.S. Douches, J. Coombs, K. Zarka, G. Steere, D. Kells, M. Zuehlke, C. Long, W. Kirk, and J. Hao

Department of Plant, Soil, and Microbial Sciences
Michigan State University
East Lansing, MI 48824

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 Center (MRC). In 2012, we tested 180 varieties and breeding lines in the replicated variety trials, plus single observational plots of 107 lines and 60 replicated lines in the National Chip Processing Trial. The variety evaluation also includes disease testing in the scab nursery (MSU Soils Farm, E. Lansing and Montcalm Research Farm, Lakeview) and foliar and tuber late blight evaluation (Muck Soils Research Farm, Bath). The objectives of the evaluations are to identify superior varieties for fresh or chip-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.

We would like to acknowledge the collaborative effort of Bruce Sackett, Chris Long and the Potato Breeding Team (especially N. Garrity, A. McKenna, S. Mambetova) for getting the research done.

PROCEDURE

The field variety trials were conducted at the Montcalm Research Center 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 on the Comden ground that was in corn the previous 3 years and in potatoes four years previously.

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), Preliminary (chip-processors and tablestock), the NCPT and the early and late observational trials. This year, the Advanced and Adaptation chip-processing trials were combined as a single trial. *The early observational trial is discussed in the breeding report.*

2012 was the third year of the National Chip Processing Trial (NCPT). The purpose of the trial is to evaluate early generation breeding lines from the US public breeding programs for their use in chip-processing. The NCPT has 10 sites (North: NY, MI, WI, ND, OR and South: NC, FL, MO, CA, TX) in addition to a scab trial in MN. A total of 167 lines were tested as 15-hill single observation plots. *The NCPT trial is discussed in the breeding report.*

In each of these trials, the yield was graded into four size classes, incidence of external and internal defects in >3.25 in. (8.25 cm) diameter (or 10 oz. (283.5 g) for Russet types) potatoes were recorded. Samples were taken for specific gravity, chipping, disease tests and bruising tests. Chip quality was assessed on 25-tuber composite sample from four replications, taking two slices from each tuber. Chips were fried at 365°F (185°C). The chip color was measured visually with the SFA 1-5 color chart. Tuber samples were also stored at 45°F (7.2°C) and 50°F (10°C) for chip-processing out of storage in January and March. Advanced selections are also placed in the MPIC B.F. Burt Cargill Commercial Demonstration Storage in Entrican, MI for monthly sampling. The lines in the agronomic trials were assessed for common scab resistance at the nursery at the Montcalm Research Farm. There has been very strong scab disease pressure at the new Montcalm Scab Disease Nursery for three years now. The 2012, late blight trial was again conducted at the Clarksville Research Center. Maturity ratings (1 early - 5 late) were taken for all variety trial plots in late August to differentiate early and late maturing lines. The simulated blackspot bruise results for average spots per tuber have also been incorporated into the summary sheets.

RESULTS

A. Advanced and Chip-Processing Trial (Table 1)

The Advanced Trial and the Adaptation Chip-Processing Trial were combined in 2012. A summary of the 30 entries evaluated in the trial results is given in **Table 1**. Overall, the yields for the Advanced trial (131 days) were above average. The check varieties for this trial were Snowden , Atlantic, and Pike. The highest yielding lines were AC03452-2W, MSQ131-A, NY140, MSQ086-3, NY148, MSS206-2, and MSR127-2. Hollow heart and vascular discoloration were the predominant internal defects; however, the amount of hollow heart was lower than average (only 7% HH in Atlantic). Specific gravity was slightly below average with seven lines having a specific gravity equal to or higher than Snowden (1.080): Lamoka (1.080), MSR128-4Y (1.083), Atlantic (1.084), MSR127-2 (1.084), MSS165-2Y (1.085), MSN190-2 (1.090) and NY148 (1.093). All chip-processing entries in the trial had excellent chip-processing quality out of the field, with an SFA score of 1.0 or 1.5. Many of the MSU breeding lines have moderate to strong scab resistance, including: MSJ126-9Y, MSL007-B, MSR169-8Y and MSP270-1.

Two promising chip-processing lines are MSL292-A (chip quality, high yield, good specific gravity, and shows potential as a long-term storage chipper) and MSQ086-3 (good yield and chip quality). A new line of interest is MSR127-2 (strong yield, high specific gravity, scab resistance, and good chip quality).

B. North Central Regional Trial Entries (Table 2)

The North Central Trial is conducted in a wide range of environments (6 regional locations) to provide adaptability data for the release of new varieties from Michigan, Minnesota, North Dakota, Wisconsin, and Canada. Sixteen entries were tested in Michigan in 2012. The results are presented in **Table 2**. Due to seed availability, there were no entries from MSU in the 2012 North Central Regional Trial. The entries from Wisconsin, Minnesota, and North Dakota had lower than average yields and smaller size profiles, with a large percentage of B-size tubers.

C. Russet Trial (Table 3)

We continue to increase our russet breeding efforts to reflect the growing interest in russet types in Michigan. In 2012, 22 lines were evaluated after 131 days. The results are summarized in **Table 3**. Russet Burbank, Russet Norkotah, Silverton Russet and GoldRush were the reference varieties used in the trial. The highest yielding lines were W7449-1Rus, Silverton Russet, Dakota Trailblazer, AF3362-1Rus, Teton Russet, and W6234-4Rus. There was a high incidence of hollow heart (73% in Russet Norkotah LT, 70% in Dakota Trailblazer, 50% in AND00618-2RussY, and 45% in both Teton Russet and Russet Norkotah) and vascular discoloration in the internal quality. Specific gravity measurements were average to below average with Russet Norkotah at 1.065 and Russet Burbank at 1.067. Off type and cull tubers were found in nearly all lines tested, with the highest being Russet Burbank (21%). In general, the Colorado russet lines had the lowest yields and a high percentage of B-sized tubers.

D. Adaptation Trials (Table 4)

This year the Adaptation Trial for chip-processing lines was combined with the Advanced Trial (Table 1). The Adaptation Trial of the tablestock lines was harvested after 131 days and the results are summarized in **Table 4**. The majority of the lines evaluated in the Adaptation Trial were tested in the Preliminary Trial the previous year. Three reference cultivars (Onaway, NorWis, and Yukon Gold), and 17 advanced breeding lines are reported in the tablestock trial. In general, the yields were average in this trial and internal defects were low, with Yukon Gold having the most hollow heart (20%). The highest yielding lines were Reba, MSR216-AP, and MSS576-05SPL. Promising and attractive yellow-fleshed table selections are MSM288-2Y and MSQ341-BY. MSL211-3 is round-oval white with bright skin, early maturity, and excellent internal quality. MSQ176-5 is uniformly round, bright white skinned potato and has demonstrated late blight resistance to both US-8 and US-22. MSS544-1R and MSR217-1R have attractive red color. We continue to evaluate breeding lines with specialty market potential (purple skin such as MSR216-AP and MSR214-2P; splashes of color such MSS576-05SPL, Spartan Splash, and Purple Haze; and red-skin, purple flesh such as Purple Heart).

E. Preliminary Trials (Tables 5 and 6)

The Preliminary trial is the first replicated trial for evaluating new advanced selections from the MSU potato breeding program. The division of the trials was based upon pedigree assessment for chip-processing and tablestock utilization. The chip-processing Preliminary Trial (**Table 5**) had 43 advanced selections and three check varieties (Atlantic, Pike and Snowden). Results are shown for 26 lines and the controls. The chip-processing trial was harvested after 133 days. Most lines chip-processed well from the field. Specific gravity values were below average with Atlantic at 1.081 and Snowden at 1.075. Nine advanced selections had 1.079 or higher specific gravities. Internal quality was good across all the lines in the trial. Promising MSU lines are MSS934-4, MSW485-2, MSW259-6, and MSW140-3, combining yield, specific gravity, and chip quality. We continue to make progress selecting chip-processing with scab resistance and late blight resistance.

Table 6 summarizes 23 of the 30 tablestock lines evaluated in the Preliminary Trial (Onaway and Reba were the check varieties). This tablestock trial was harvested and evaluated after 133 days. MSW123-3, CF7523-1, Reba, MSW125-3, and MSS487-2 were the highest yielding lines. This trial also had a low incidence of internal defects, with Reba having the most hollow heart (35%). The number of tablestock selections with scab resistance and late blight resistance continue to increase. In addition to traditional round white, red-skinned, and yellow flesh freshmarket categories, there are some unique specialty lines such as MSR226-ARR and MSW148-1P.

F. Potato Common Scab Evaluation (Table 7)

Each year, a replicated field trial is conducted to assess resistance to common scab. We have moved the scab testing to two ranges at the Montcalm Research Center where high common scab disease pressure was observed in previous years. This location is being used for the early generation observational scab trial (over 375 lines), the scab variety trial (~170 lines), the scab trial of a tetraploid mapping population (>200 progeny) and the national scab trial sponsored by USDA/ARS. *Additionally, we conducted a second year of the replicated On-Farm scab trial (24 lines), which is summarized in the MPIC Research Report.*

We use a rating scale of 0-5 based upon a combined score for scab coverage and lesion severity. Usually examining one year's data does not indicate which varieties are resistant but it should begin to identify ones that can be classified as susceptible to scab. Our goal is to evaluate important advanced selections and varieties in the study at least three years to obtain a valid estimate of the level of resistance in each line. The 2010-

2012 scab ratings are based upon the Montcalm Research Center site. **Table 7** categorizes many of the varieties and advanced selections tested in 2012 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 Burbank, Russet Norkotah, GoldRush, Red Norland, Red Pontiac, Yukon Gold, Onaway, Pike, Atlantic, and Snowden can be used as references (bolded in **Table 7**). The table is sorted in ascending order by 2012 scab rating. This year's results continue to indicate that we have been able to breed numerous lines with resistance to scab. A total of 52 lines, of the 161 tested, had a scab rating of 1.5 or lower in 2012. Most notable scab resistant MSU lines are MSJ126-9Y, MSL007-B, MSN215-2P, MSP270-1, MSQ279-1, MSR061-1, MSR127-2 and MSR169-8Y; as well as some earlier generation lines MSS297-3, MST096-2Y, MST096-4, MST441-1, MSW509-2, and MSW125-3. 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 two years of selection. Of the 379 early generation selections that were evaluated, over 117 had scab resistance (scab rating of ≤ 1.5). Scab results from the disease nursery for the advanced selections are also found in the Trial Summaries (**Tables 1-6**).

H. Late Blight Trial (Tables 8, 9, and 10)

In 2012, the late blight trial was planted again at the Clarksville Research Center rather than the Muck Soils Research Farm. Over 300 entries were planted in early June for late blight evaluation. These include lines tested in a replicated manner from the agronomic variety trial (162 lines) and entries in the National Late Blight Variety Trial (37 lines) and about 200 entries in the early generation observation plots. The trials were inoculated in early August with a US-22 genotype of *P. infestans*. Late blight infection was identified in the plots within 2 weeks after inoculation. The plots were evaluated 1-2 times per week over a 50 day period following inoculation. The disease reaction in the plots was not as aggressive as previous years when US-8 was predominant. In 2012, there were 27 lines from the national late blight trial that had moderate to strong late blight resistance to US-22. For the replicated variety trial 54 lines had moderate to strong late blight resistance, while 87 lines in the early generation observation plots had moderate to strong late blight resistance. These were from various late blight resistance sources in the pedigree of the selections (LBR9, Malinche, Kenya Baraka, Monserrat, Torridon, Stirling, NY121, B0718-3, etc.). **Tables 9, 10 and 11** list the foliar late blight disease ratings for select lines based on percent disease over time (RAUDPC; Relative Area Under the Disease Progress Curve).

I. Blackspot Bruise Susceptibility (Table 12)

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

In 2012, the bruise levels were comparable to previous years. The most bruise resistant MSU breeding lines this year from the Advanced/Adaptation Chip-processing Trial were MSR148-4, MSJ126-9Y, MSQ131-A, MSQ440-2 and MSS206-2. The most susceptible lines from the Advanced trial were MSP516-A, MSQ035-3, and NY148 (E106-4). The most bruise resistant russet entries were CO04233-1Rus, AF3362-1Rus, and A01124-3Rus; the most susceptible were CO03187-1Rus, ND8068-5Rus, and Dakota Trailblazer. The Adaptation Trial MSU lines (Tablestock) with the least bruising were MSM288-2Y, NY150, MSR214-2P, MSQ176-5, MSS582-2SPL, and MSS544-1R. MSR216-AP, MSE149-5Y, Purple Heart, and Reba were the most bruise susceptible. Of the earlier generation breeding lines (Preliminary Trials), the most of the lines had little blackspot bruising, with MSW474-1, MSW509-5, MSW140-3, and MSW443-3 showing significant blackspot bruising for chip-processing lines, and MSW148-1P and CF7523-1 for tablestock lines. The most bruise resistant entries in the US Potato Board/Snack Food Association Trial were AF4157-6, CO00188-4W, W6483-5, CO00197-3W, W2978-3, A01143-3C and MSL292-A, while NY148, ND8305-1, and W5015-12 had more bruising than Atlantic.

Table 1

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADVANCED and CHIP-PROCESSING TRIAL
MONTCALM RESEARCH FARM
May 10 to September 17, 2012 (131 days)

										PERCENT (%)							LB	3-YR AVG
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]							RAUDPC	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]	x100	CWT/A
AC03452-2W	532	583	91	7	73	19	2	1.068	1.0	5	0	0	0	2.5	2.9	1.1	-	-
MSQ131-A	421	427	99	1	67	32	0	1.067	2.0	1	0	0	0	1.9	1.6	0.6	12.0	-
NY140[LBR]	399	433	92	7	89	3	0	1.077	1.0	0	19	0	0	2.8	2.6	1.8	2.6	372*
MSQ086-3[LBR]	398	498	80	19	79	1	1	1.074	1.0	0	9	0	0	1.9	2.5	1.8	4.4	363
NY148[LBR]	376	469	80	20	78	2	0	1.093	1.5	0	2	0	0	1.8	2.8	3.2	1.4	370*
MSS206-2	374	410	91	6	79	12	2	1.063	2.0	0	12	0	0	1.6	2.1	0.6	9.1	439*
MSR127-2	370	402	92	8	83	9	0	1.084	1.0	0	3	0	0	1.5	2.5	2.3	-	381*
Lamoka	357	382	93	6	88	5	1	1.080	1.5	0	13	0	0	1.5	1.4	2.0	13.5	381
MSQ279-1	347	387	90	8	73	17	2	1.072	1.5	2	3	0	0	1.3	2.6	1.1	-	345
MSQ089-1	339	381	89	11	86	3	0	1.070	1.5	0	6	0	0	1.9	2.3	0.7	10.0	340*
MSS165-2Y	333	444	75	25	74	1	0	1.085	1.0	0	9	0	0	1.9	2.5	2.2	6.1	310*
MSL292-A	312	357	87	13	82	6	0	1.077	1.0	0	6	0	0	2.5	1.1	1.1	-	341
MSQ035-3	312	403	77	22	77	0	1	1.078	1.5	0	1	0	0	1.4	1.5	4.1	13.6	385
MSL007-B	306	376	81	18	81	1	0	1.078	1.0	0	8	0	0	1.5	1.9	1.7	-	296
CO02321-4W	305	363	84	16	81	3	0	1.078	1.0	1	5	0	0	2.8	1.0	1.4	-	334*
FL1879	303	334	91	9	83	7	0	1.074	1.0	1	10	0	0	2.3	1.4	1.7	19.7	322
Atlantic	**289**	**336**	**86**	**14**	**81**	**5**	**0**	**1.084**	**1.0**	**7**	**4**	**1**	**0**	**2.8**	**1.4**	**1.8**	**24.1**	**308**
MSN190-2	283	384	74	26	72	2	0	1.090	1.0	0	7	0	0	1.5	1.0	2.1	-	271*
MSP516-A[LBR]	281	334	84	15	79	5	0	1.074	1.5	6	13	0	0	1.4	2.3	4.3	2.3	-
W4980-1	276	318	87	13	82	4	0	1.077	1.0	0	4	3	0	1.9	1.1	2.7	24.6	-
AC00206-2W	257	305	84	15	82	2	0	1.074	1.0	0	3	0	0	3.8	1.3	0.7	-	-
MSJ126-9Y	249	309	81	19	80	0	0	1.075	1.0	0	11	2	0	0.8	1.5	0.6	-	235
Snowden	**249**	**342**	**73**	**27**	**72**	**0**	**0**	**1.080**	**1.0**	**0**	**17**	**0**	**0**	**2.6**	**1.4**	**1.4**	**15.8**	**312**
MSR061-1[LBMR,PVYR]	241	299	81	19	79	1	0	1.076	1.5	1	12	0	0	1.9	1.4	1.3	1.1	225
MSQ440-2	235	280	84	16	81	3	0	1.057	N/A	0	29	0	0	1.5	1.0	0.6	15.8	245
Pike	**214**	**280**	**76**	**24**	**76**	**0**	**0**	**1.079**	**1.0**	**0**	**10**	**0**	**0**	**1.1**	**1.4**	**0.5**	**22.9**	**208**
MSP270-1	202	252	80	20	79	1	0	1.069	1.0	0	4	0	0	0.8	2.5	1.9	-	212
MSR148-4	196	296	66	34	66	1	0	1.065	1.0	0	12	0	0	2.3	1.3	0.2	-	338
MSR169-8Y	188	251	75	25	72	2	0	1.077	1.0	2	12	0	0	0.8	1.5	1.6	-	239
MSR128-4Y	173	239	72	27	70	2	1	1.083	1.0	4	1	0	0	1.5	2.1	0.8	-	153*
MEAN	304	362						1.076						1.9	1.8	1.6	11.7	
$HSD_{0.05}$	132	131						0.006						1.4	0.7	-	21.5	

* Two-Year Average

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), **LBMR** lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.

[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 30, 2012; 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.

<Back Contents Next> Print Quit

Table 2

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
May 10 to September 17, 2012 (131 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]							LB	3-YR AVG
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	RAUDPC x100	US#1 CWT/A
W8405-1R	331	439	75	24	75	0	0	1.056	N/A	0	13	0	0	2.5	1.1	1.0	22.6	-
NorValley	**311**	**408**	**76**	**19**	**75**	**1**	**4**	**1.070**	**1.5**	**0**	**10**	**0**	**3**	**3.0**	**1.0**	**2.6**	**26.1**	**314**
Snowden	**306**	**372**	**82**	**18**	**80**	**3**	**0**	**1.077**	**1.0**	**8**	**40**	**0**	**0**	**2.6**	**1.4**	**1.4**	**15.8**	**328**
Atlantic	**297**	**336**	**88**	**12**	**84**	**4**	**0**	**1.082**	**1.0**	**10**	**13**	**0**	**0**	**2.8**	**1.3**	**2.0**	**24.1**	**310**
Red Pontiac	**296**	**372**	**80**	**8**	**67**	**13**	**13**	**1.055**	**N/A**	**20**	**43**	**0**	**3**	**3.4**	**1.5**	**1.2**	**9.9**	**300**
W5015-12	275	385	71	28	69	2	0	1.081	1.0	5	40	0	0	2.6	2.0	1.6	11.9	324*
Dk. Red Norland	**251**	**272**	**92**	**8**	**87**	**6**	**0**	**1.083**	**2.5**	**8**	**45**	**5**	**0**	**1.4**	**1.0**	**0.3**	**32.7**	**245**
MN02586	243	362	67	32	67	0	0	1.066	N/A	0	10	0	0	2.8	1.0	0.8	17.6	212*
MN02467[LBMR]	240	361	66	30	65	2	3	1.076	N/A	20	0	0	0	1.5	1.8	1.8	5.2	-
ND7519-1	239	341	70	29	70	0	1	1.079	1.0	0	23	0	3	2.4	1.0	1.4	21.2	-
W6002-1R	239	300	80	20	78	2	0	1.052	N/A	0	5	0	0	2.3	1.1	0.2	25.1	219*
MN18747	215	270	80	18	78	2	2	1.058	1.0	0	28	0	0	2.4	1.0	0.3	27.3	-
Lelah (W2717-5)	211	266	79	20	78	1	1	1.084	1.0	10	18	3	3	2.6	1.0	1.0	-	225
ND08305-1	170	277	62	38	62	0	0	1.082	1.0	0	3	0	0	3.1	1.1	2.8	20.7	-
MN02419[LBMR]	160	299	53	39	52	1	7	1.078	N/A	10	20	0	0	2.9	1.8	1.8	3.5	-
MN04844-01[LBMR]	131	243	54	46	54	0	0	1.072	1.0	0	55	3	0	2.0	1.0	0.8	5.9	-
MEAN	245	331						1.072	1.2					2.5	1.3	1.3	18.0	
$HSD_{0.05}$	82	77						0.006						1.4	0.6	-	21.5	

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), [LBMR] lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.

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 30, 2012; 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

RUSSET TRIAL
MONTCALM RESEARCH FARM
May 10 to September 17, 2012 (131 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							LB RAUDPC	3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	x100	CWT/A
W7449-1Rus	390	460	85	14	82	3	1	1.077	13	10	5	0	1.8	2.3	0.5	6.8	-
Silverton Russet	359	418	86	12	65	21	2	1.064	18	5	5	0	0.8	2.3	0.6	11.9	293
Dakota Trailblazer[LBR]	349	389	89	7	64	25	3	1.089	70	23	0	0	2.4	3.0	1.7	2.2	269*
AF3362-1Rus	328	354	93	3	52	41	4	1.067	0	40	3	0	1.3	1.5	0.2	21.9	295*
Teton Russet	325	398	82	14	63	19	4	1.064	45	15	3	0	0.4	1.0	0.7	21.5	-
W6234-4Rus	323	385	84	12	69	15	4	1.077	8	28	0	0	2.5	1.3	1.2	16.6	312*
A01124-3Rus	308	372	83	9	61	22	8	1.072	30	5	0	0	1.5	2.0	0.5	12.4	287
A02062-1TE	271	324	84	9	51	33	8	1.065	5	18	0	0	1	1.9	0.7	11.6	239*
Russet Norkotah	**224**	**291**	**77**	**23**	**65**	**12**	**0**	**1.065**	**45**	**18**	**3**	**0**	**1.9**	**1.1**	**0.6**	**8.4**	**189**
Russet Norkotah TX223	221	278	79	18	67	12	3	1.064	35	38	0	0	2.3	1.1	0.9	16.0	-
Russet Norkotah LT	202	264	77	21	67	9	3	1.066	73	20	0	0	2.1	1.9	0.8	4.2	-
GoldRush Russet	**181**	**282**	**64**	**27**	**60**	**4**	**9**	**1.061**	**0**	**35**	**0**	**0**	**0.8**	**1.3**	**0.9**	**15.6**	**198**
CO03276-5Rus	177	324	55	40	52	3	6	1.069	10	18	0	0	0.3	1.0	nd	21.6	169*
CO03276-4Rus	174	325	53	44	52	2	3	1.069	0	40	0	0	0.1	1.1	nd	12.5	136*
AND00618-2RussY	171	236	72	25	71	1	3	1.077	50	3	0	0	0.9	2.0	0.6	7.3	-
CO04233-1Rus[LBMR]	157	217	72	21	71	2	6	1.062	8	10	0	0	0.8	1.0	0.2	6.6	-
CO04159-1RY	149	220	68	31	68	0	1	1.056	0	23	0	0	2.1	1.0	0.1	20.1	-
CO03187-1Rus	143	294	49	49	47	2	2	1.072	0	18	0	5	0.6	1.3	2.1	26.5	137*
CO04211-4Rus	141	224	63	35	61	2	3	1.066	3	28	23	0	1.4	1.3	0.8	23.1	-
CO04220-7Rus	136	270	50	47	49	2	3	1.065	5	48	0	0	0.9	1.0	0.8	26.0	-
Russet Burbank	**125**	**265**	**47**	**32**	**45**	**2**	**21**	**1.067**	**5**	**13**	**8**	**0**	**2.1**	**2.0**	**0.5**	**7.2**	**109**
ND8068-5Rus	124	190	65	35	64	1	0	1.071	3	23	0	0	2.4	1.0	2.0	32.0	119*
MEAN	226	308						1.068					1.4	1.5	0.8	15.1	
$HSD_{0.05}$	104	112						0.007					1.4	0.7	-	21.5	

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), [LBMR] lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.

[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 30, 2012; 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 4

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 10 to September 17, 2012 (131 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							LB RAUDPC
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	x100
Reba	404	429	94	5	85	9	1	1.070	10	33	0	0	2.2	1.9	1.2	29.2
MSR216-AP	398	435	92	8	86	5	0	1.070	0	30	0	0	2.9	1.9	2.3	14.9
MSS576-05SPL	374	458	82	18	79	2	0	1.072	0	5	0	0	1.9	2.0	0.9	13.4
Onaway	**356**	**387**	**92**	**6**	**84**	**8**	**2**	**1.059**	**0**	**63**	**0**	**0**	**1.9**	**1.1**	**1.0**	**29.2**
NorWis	**348**	**381**	**91**	**5**	**78**	**13**	**4**	**1.066**	**3**	**35**	**0**	**0**	**2.3**	**1.6**	**0.7**	**-**
MSE149-5Y	333	375	89	11	79	10	0	1.066	0	25	0	0	2.0	1.5	1.6	-
MSR214-2P	302	373	81	19	81	0	0	1.064	0	0	0	0	1.9	2.5	0.3	7.1
Michigan Purple	297	343	87	7	71	15	7	1.067	8	28	0	0	2.1	1.0	0.9	-
MSM288-2Y	294	383	77	23	75	1	0	1.068	0	3	0	0	2.8	1.0	0.0	-
Red Norland	281	334	84	15	84	1	0	1.057	0	43	0	0	1.5	1.0	0.0	-
Purple Heart	271	331	82	18	81	1	0	1.058	0	0	0	0	2.6	1.4	1.4	21.8
MSL211-3	253	293	86	13	82	5	1	1.066	0	28	0	0	1.9	1.0	0.7	22.0
Purple Haze	249	279	89	9	77	12	2	1.070	3	40	0	0	1.9	1.4	0.8	-
MSQ176-5[LBR]	244	280	87	13	76	11	0	1.061	13	15	0	0	2.3	1.6	0.4	2.1
MSQ341-BY	221	258	86	14	83	3	0	1.071	0	20	0	3	1.4	2.0	1.0	-
Spartan Splash	206	294	70	30	70	0	0	1.068	0	18	0	0	1.8	1.0	0.8	-
MSS544-1R	174	312	56	44	56	0	0	1.057	0	13	0	0	1.4	1.0	0.5	-
MSR217-1R	163	214	76	22	76	0	2	1.053	0	8	0	0	2.8	1.3	0.8	7.7
Yukon Gold	**159**	**176**	**90**	**9**	**80**	**10**	**0**	**1.061**	**20**	**8**	**0**	**0**	**3.0**	**1.0**	**0.3**	**26.4**
MSS582-2SPL	114	237	48	52	48	0	0	1.090	0	28	0	0	0.8	1.3	0.5	18.1
NY150	22	211	10	90	10	0	0	1.071	0	10	0	0	2.3	1.1	0.0	10.7
MEAN	260	323						1.066					2.1	1.4	0.8	16.9
$HSD_{0.05}$	101	98						0.006					1.4	0.8	-	21.5

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), [LBMR] lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.

[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 30, 2012; 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

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 10 to September 19, 2012 (133 days)

	CWT/A		PERCENT OF TOTAL[1]							PERCENT (%) TUBER QUALITY[3]							LB RAUDPC
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	x100
MSS934-4[LBMR]	448	513	87	13	77	10	0	1.081	1.5	5	35	0	0	2.9	2.5	0.5	4.4
MSW485-2[LBR]	422	489	86	13	82	4	1	1.089	1.5	0	20	0	0	2.0	3.0	0.4	1.4
MSW509-5	412	457	90	8	80	10	1	1.073	1.5	20	15	0	0	0.5	2.0	2.6	-
MSW259-6	394	439	90	10	81	9	0	1.081	1.0	35	0	0	0	2.0	3.0	0.9	8.6
MSW140-3	390	447	87	12	85	2	1	1.085	1.0	0	10	0	0	1.0	1.8	2.5	7.3
MSW360-18[LBR]	390	468	83	16	81	2	1	1.075	1.0	5	25	0	0	3.0	2.0	0.5	1.5
MSS927-1	364	414	88	12	76	12	0	1.077	1.0	0	10	0	0	1.9	2.5	-	16.2
MSW168-2[LBR]	353	374	94	6	71	23	0	1.082	2.0	45	15	0	0	1.5	3.0	1.2	1.3
MST424-3	344	367	94	5	83	10	1	1.074	1.0	5	40	0	0	1.4	1.8	2.1	-
MST412-3	343	372	92	5	78	14	2	1.076	2.5	35	30	0	0	1.6	2.3	0.8	6.4
Atlantic	**322**	**367**	**88**	**10**	**85**	**3**	**2**	**1.081**	**1.5**	**20**	**20**	**0**	**0**	**2.8**	**1.3**	**1.9**	**24.1**
MST178-2	320	353	91	9	89	1	0	1.068	-	0	20	0	0	1.1	2.0	-	-
MSW075-1	310	375	83	17	80	3	0	1.076	1.0	5	15	0	0	1.5	2.8	0.7	-
MSQ492-2[LBMR]	305	400	76	24	74	2	0	1.073	1.0	0	20	0	0	1.6	3.0	0.4	3.4
MSW464-3[LBR]	302	332	91	8	75	16	1	1.080	1.5	25	20	0	0	2.0	3.0	0.3	1.4
MSW138-2	296	346	86	14	84	2	0	1.077	1.0	0	35	0	0	2.0	1.0	0.5	-
MSW474-1[LBMR]	294	391	75	25	75	1	0	1.081	1.0	0	10	0	0	0.0	2.8	3.3	3.3
MSW437-9	291	309	94	6	79	15	0	1.064	1.0	5	15	0	0	2.0	1.0	0.4	9.9
MSS297-3	284	358	79	21	79	1	0	1.075	1.0	0	0	0	0	0.8	1.0	0.6	-
MST096-2Y	278	324	86	14	85	1	0	1.068	1.0	0	10	0	0	0.9	1.3	0.2	-
Snowden	**277**	**340**	**82**	**18**	**79**	**3**	**0**	**1.075**	**1.0**	**0**	**15**	**0**	**0**	**2.6**	**1.3**	**0.7**	**15.8**
MSR054-7	264	335	79	21	78	1	0	1.072	-	0	15	0	0	1.4	1.8	0.2	7.8
Pike	**226**	**313**	**72**	**28**	**72**	**0**	**0**	**1.075**	**1.0**	**0**	**30**	**5**	**0**	**1.1**	**2.3**	**0.6**	**22.9**
MSW078-1[LBR]	224	306	73	27	73	0	0	1.087	-	0	0	0	0	2.0	1.5	-	1.3
MST184-3	223	272	82	18	79	3	0	1.078	1.0	10	25	0	0	1.6	1.5	0.7	-
MST096-4	220	310	71	29	71	0	0	1.068	1.5	0	5	0	0	0.4	1.3	0.8	-

Table 5

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
May 10 to September 19, 2012 (133 days)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]							LB RAUDPC
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	x100
MSW068-4	217	269	81	19	79	2	0	1.070	1.0	0	45	0	0	1.4	1.0	-	-
MST441-1	212	310	68	32	68	0	0	1.077	2.5	0	5	0	0	0.6	1.3	0.8	-
MSW443-3	212	334	63	37	63	0	0	1.079	1.0	5	15	0	0	2.0	1.5	2.4	-
MEAN	308	368						1.076						1.6	2.0	1.0	8.1
$HSD_{0.05}$	207	212						0.011						1.4	1.3	-	21.5

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), **LBMR** lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.

[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 30, 2012; 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

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
May 10 to September 19, 2012 (133 days)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[3]							LB RAUDPC
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[4]	MAT[5]	BRUISE[6]	x100
MSW123-3	470	490	96	4	72	24	0	1.065	0	20	0	0	2.0	1.3	1.6	28.9
CF7523-1	437	515	85	14	84	1	1	1.070	0	20	0	0	3.1	1.8	2.4	-
Reba	402	423	95	4	79	16	1	1.067	35	15	0	0	2.2	2.0	1.2	29.2
MSW125-3	388	435	89	8	80	9	3	1.054	5	25	5	0	1.0	1.0	0.7	25.1
MSS487-2[LBR]	386	454	85	15	85	0	0	1.078	0	0	0	0	2.1	2.5	1.8	1.5
Onaway	**382**	**414**	**92**	**8**	**76**	**16**	**0**	**1.056**	**0**	**45**	**5**	**0**	**1.9**	**1.0**	**1.2**	**29.2**
MST065-1	355	429	83	17	79	3	0	1.075	0	10	0	5	2.6	2.5	1.0	10.2
MSW128-2[LBR]	338	367	92	7	68	24	1	1.062	20	5	0	0	3.0	2.5	0.4	1.7
W6703-5Y	319	382	84	9	81	3	7	1.070	0	25	5	0	1.1	3.3	0.9	4.5
MSW239-3	312	376	83	14	83	0	3	1.047	0	25	0	0	1.5	1.0	0.3	-
MSW151-9[LBR]	310	394	79	17	75	4	5	1.071	20	15	0	0	2.5	2.5	0.8	2.2
MSW273-3R	308	363	85	11	84	1	4	1.063	10	15	0	0	2.0	1.0	0.5	18.7
MSW121-5R	283	349	81	18	81	0	1	1.051	0	0	0	0	1.0	1.0	0.6	12.1
MSW122-9	278	324	86	11	76	10	4	1.062	0	5	0	0	2.0	1.3	0.7	18.3
W6703-1Y	274	330	83	15	83	0	1	1.076	0	5	0	0	1.1	2.5	1.0	4.2
MSW027-1	259	306	84	16	84	0	0	1.062	0	15	0	0	2.0	1.0	1.0	19.8
MSW153-1[LBMR]	248	300	83	17	83	0	0	1.074	0	25	15	0	1.0	1.8	1.9	3.1
MSW500-4[LBMR]	211	235	90	9	90	0	1	1.075	0	0	0	0	2.0	1.8	1.5	3.3
MSR226-ARR	199	291	68	28	62	7	3	1.070	0	15	20	0	1.4	2.5	1.2	-
MSW148-1P	194	405	48	51	48	0	1	1.080	0	25	0	0	2.0	2.0	2.7	7.9
MSW298-4Y	168	278	60	40	60	0	0	1.068	0	10	0	0	2.5	1.0	0.5	21.7
MSW182-1Y	109	264	41	58	41	0	1	1.078	5	25	10	0	2.0	1.5	1.8	-
MEAN	301	369						1.067					1.9	1.8	1.2	13.4
$HSD_{0.05}$	250	244						0.013					1.4	2.3	-	21.5

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*), [LBMR] lines showed moderate resistance, in inoculated field trials at the MSU Clarksville Research Center.
[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 30, 2012; 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.

<Back Contents Next> Print Quit

Table 7

2010-2012 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER , MI

LINE	*3-YR* AVG.*	2012 RATING	2012 WORST	2012 N	2011 RATING	2011 WORST	2011 N	2010 RATING	2010 WORST	2010 N
Sorted by ascending 2012 Rating;										
CO03276-4Rus	***.8****	0.1	1	4	1.5	3	4	-	-	-
CO03276-5Rus	***.7****	0.3	1	4	1.1	2	4	-	-	-
MST096-4	-	0.4	1	4	-	-	-	-	-	-
Teton Russet	-	0.4	1	4	-	-	-	-	-	-
CO03187-1Rus	***.4****	0.6	1	4	0.1	1	4	-	-	-
MST441-1	***0.9****	0.6	1	4	-	-	-	1.3	2	2
CO04233-1Rus[LBMR]	-	0.8	2	4	-	-	-	-	-	-
Goldrush Russet	***0.8***	**0.8**	**2**	**4**	**0.5**	**1**	**4**	**1.0**	**1**	**2**
MSJ126-9Y	***0.8***	0.8	2	4	0.8	2	4	1.0	1	2
MSP270-1	***0.8***	0.8	1	4	0.6	1	4	1.0	1	2
MSR131-2	***0.9****	0.8	1	4	-	-	-	1.0	1	2
MSR169-8Y	***0.8***	0.8	2	4	0.6	1	4	1.0	1	2
MSS297-3	***0.8***	0.8	1	4	0.9	1	4	0.9	1	4
MSS582-1SPL	***1.6***	0.8	1	4	2.0	3	4	2.0	2	2
Silverton Russet	***0.8***	0.8	2	4	0.5	1	4	1.0	1	2
AND00618-2RUS	-	0.9	2	4	-	-	-	-	-	-
CO04220-7RUS	-	0.9	2	4	-	-	-	-	-	-
MST096-2Y	-	0.9	2	4	-	-	-	-	-	-
MSW509-5	-	0.9	2	4	-	-	-	-	-	-
A02062-1TE	***.8****	1.0	2	4	0.6	1	4	-	-	-
MSW125-3	-	1.0	1	4	-	-	-	-	-	-
MSJ042-3	-	1.1	2	4	-	-	-	-	-	-
MST178-2	-	1.1	2	4	-	-	-	-	-	-
MSW140-3	-	1.1	2	4	-	-	-	-	-	-
MSW326-6	-	1.1	2	4	-	-	-	-	-	-
MSW474-1	-	1.1	2	4	-	-	-	-	-	-
Pike	***1.2***	**1.1**	**2**	**8**	**1.5**	**3**	**4**	**1.1**	**2**	**8**
W6703-1Y	-	1.1	2	4	-	-	-	-	-	-
W6703-5Y	-	1.1	2	4	-	-	-	-	-	-
AF3362-1Rus	***1.2****	1.3	2	4	1.1	2	4	-	-	-
MSQ279-1	***1.2***	1.3	2	4	1.0	2	4	1.3	2	2
MSW100-1	-	1.3	2	4	-	-	-	-	-	-
MSW502-4	-	1.3	2	4	-	-	-	-	-	-
CO02411-4RUS	-	1.4	2	4	-	-	-	-	-	-
Dark Red Norland	***1.5***	**1.4**	**2**	**4**	**1.3**	**2**	**4**	**2.0**	**2**	**2**
MSP516-A[LBR]	-	1.4	2	4	-	-	-	-	-	-
MSQ035-3[LBR]	***1.4***	1.4	2	4	1.8	3	4	1.0	1	2
MSQ341-BY	***1.4***	1.4	2	4	1.3	2	4	1.5	2	2
MSR054-7	-	1.4	2	4	-	-	-	-	-	-
MSR058-1	***1.3***	1.4	2	4	1.0	2	4	1.5	2	2
MSR226-ARR	-	1.4	2	4	-	-	-	-	-	-
MSS544-1R	***1.4***	1.4	2	4	1.9	2	4	1.0	1	2
MST424-3	***1.6****	1.4	2	4	-	-	-	1.8	2	2
MSW068-4	-	1.4	3	4	-	-	-	-	-	-
A01124-3RUS	***1.4***	1.5	2	4	1.3	2	4	1.5	2	2
Lamoka (NY139)	***1.6***	1.5	2	4	1.4	2	4	2.0	2	2

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2010-2012 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER , MI

LINE	*3-YR* AVG.*	2012 RATING	2012 WORST	2012 N	2011 RATING	2011 WORST	2011 N	2010 RATING	2010 WORST	2010 N
Sorted by ascending 2012 Rating;										
MN02467	-	1.5	2	4	-	-	-	-	-	-
MSL007-B	***1.2***	1.5	2	4	1.1	2	4	1.0	1	2
MSN190-2	***1.7****	1.5	2	4	1.9	3	4	-	-	-
MSQ440-2	***1.5***	1.5	2	4	1.3	2	8	1.8	2	2
MSR127-2	***1.5***	1.5	2	4	2.0	3	4	1.0	1	2
MSR128-4Y	***1.4****	1.5	2	4	1.4	2	4	-	-	-
MSQ492-2[LBR]	-	1.6	2	4	-	-	-	-	-	-
MSS206-2	***2.1****	1.6	2	4	-	-	-	2.5	3	2
MST184-3	-	1.6	2	4	-	-	-	-	-	-
MST412-3	-	1.6	2	4	-	-	-	-	-	-
MSW343-2R	-	1.6	2	4	-	-	-	-	-	-
MSW410-12Y	-	1.6	2	4	-	-	-	-	-	-
MSW436-2Y	-	1.6	2	4	-	-	-	-	-	-
MSW501-5	-	1.6	2	4	-	-	-	-	-	-
MSW153-1	-	1.8	2	4	-	-	-	-	-	-
MSW270-1	-	1.8	3	4	-	-	-	-	-	-
NY148	***1.6****	1.8	2	4	1.4	2	4	-	-	-
Spartan Splash (MSQ425-4YSPL)	***2.2***	1.8	2	4	2.3	3	4	2.5	3	4
W6511-1R	***2.1****	1.8	3	4	2.5	3	4	-	-	-
W7449-1RUS	-	1.8	2	4	-	-	-	-	-	-
Kerrs Pink	-	1.9	3	4	-	-	-	-	-	-
MSL211-3	***1.9***	1.9	2	4	1.8	2	4	2.2	3	6
MSQ086-3[LBR]	***2.0***	1.9	2	4	2.0	3	4	2.3	3	4
MSQ089-1	***2.0****	1.9	2	4	2.1	3	4	-	-	-
MSQ131-A[LBR]	***1.9****	1.9	3	4	2.0	2	4	-	-	-
MSR061-1[LBMR,PVYR]	***1.3***	1.9	2	4	0.9	2	4	1.3	2	2
MSR214-2P	***2.0***	1.9	2	4	1.6	3	4	2.5	3	2
MSS165-2Y[LBR]	***1.8****	1.9	2	4	1.6	2	4	-	-	-
MSS576-05SPL	***1.9****	1.9	2	4	-	-	-	2.0	2	2
MSS927-1	***1.8****	1.9	2	4	1.6	3	4	-	-	-
MSW128-2	-	1.9	3	4	-	-	-	-	-	-
MSW4980-1	-	1.9	3	4	-	-	-	-	-	-
Onaway	***2.0***	**1.9**	**2**	**8**	**2.0**	**3**	**8**	**2.1**	**3**	**6**
Purple Haze	***1.8***	1.9	2	4	1.9	2	4	1.8	2	2
Russet Norkotah	***2.2***	**1.9**	**3**	**4**	**2.5**	**3**	**4**	**2.3**	**3**	**4**
MN04844-1	-	2.0	3	4	-	-	-	-	-	-
MSE149-5Y	-	2.0	2	4	-	-	-	-	-	-
MSW075-1	-	2.0	2	4	-	-	-	-	-	-
MSW168-2	-	2.0	3	4	-	-	-	-	-	-
MSW500-4	-	2.0	2	4	-	-	-	-	-	-
CO04159-1R	-	2.1	3	4	-	-	-	-	-	-
Michigan Purple	***2.4****	2.1	3	4	2.8	3	4	-	-	-
MSS487-2	-	2.1	3	4	-	-	-	-	-	-
MST235-5SPL	-	2.1	3	4	-	-	-	-	-	-
MSW121-5R	-	2.1	3	4	-	-	-	-	-	-

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2010-2012 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER , MI

LINE	*3-YR* AVG.*	2012 RATING	2012 WORST	2012 N	2011 RATING	2011 WORST	2011 N	2010 RATING	2010 WORST	2010 N
Sorted by ascending 2012 Rating;										
MSW138-2	-	2.1	3	4	-	-	-	-	-	-
MSW148-1P	-	2.1	3	4	-	-	-	-	-	-
MSW229-5P	-	2.1	3	4	-	-	-	-	-	-
MSW437-9	-	2.1	3	4	-	-	-	-	-	-
Russet Burbank	***2.2***	**2.1**	**3**	**4**	**2.4**	**3**	**4**	**2.0**	**2**	**2**
Russet Norkotah LT	-	2.1	3	4	-	-	-	-	-	-
Reba	***2.1***	2.2	3	8	1.6	2	4	2.5	3	2
FL1879	***2.7***	2.3	3	4	2.4	3	4	3.5	4	2
Lucky Joe	-	2.3	3	4	-	-	-	-	-	-
MSK049-1	-	2.3	3	4	-	-	-	-	-	-
MSQ176-5[LBR]	***2.5***	2.3	3	4	2.4	3	4	3.0	3	2
MSR148-4Y	***2.2***	2.3	3	4	1.8	2	4	2.5	3	2
MSS434-2	-	2.3	3	4	-	-	-	-	-	-
MST117-3Y	-	2.3	3	4	-	-	-	-	-	-
MSW027-1	-	2.3	3	4	-	-	-	-	-	-
MSW123-3	-	2.3	3	4	-	-	-	-	-	-
MSW252-2	-	2.3	3	4	-	-	-	-	-	-
MSW259-6	-	2.3	3	4	-	-	-	-	-	-
MSW273-3R	-	2.3	3	4	-	-	-	-	-	-
MSW464-3	-	2.3	3	4	-	-	-	-	-	-
MSW476-4R	-	2.3	3	4	-	-	-	-	-	-
NorWis	-	2.3	3	4	-	-	-	-	-	-
NY150	-	2.3	3	4	-	-	-	-	-	-
Russet Norkotah TX 223	-	2.3	3	4	-	-	-	-	-	-
W6002-1R	***2.1****	2.3	3	4	1.9	3	4	-	-	-
Dakota Trailblazer[LBR]	***2.6****	2.4	3	4	2.8	3	4	-	-	-
Kufri Jeevan	***2.3****	2.4	3	4	2.3	3	4	-	-	-
MN18747	-	2.4	3	4	-	-	-	-	-	-
MSR109-1	***2.3****	2.4	3	4	2.1	3	4	-	-	-
MSW122-9	-	2.4	3	4	-	-	-	-	-	-
MSW298-4Y	-	2.4	3	4	-	-	-	-	-	-
ND7519-1	-	2.4	4	4	-	-	-	-	-	-
ND8068-5RUS	-	2.4	3	4	-	-	-	-	-	-
AC03452-2W	-	2.5	3	4	-	-	-	-	-	-
MSE250-2	-	2.5	3	4	-	-	-	-	-	-
MSL292-A	***2.6***	2.5	3	4	2.8	4	4	2.5	3	2
MSS483-1	***2.8****	2.5	3	4	3.1	4	4	-	-	-
MSW151-9	-	2.5	3	4	-	-	-	-	-	-
MSW239-3	-	2.5	3	4	-	-	-	-	-	-
MSW324-1	-	2.5	3	4	-	-	-	-	-	-
MSW360-18	-	2.5	3	4	-	-	-	-	-	-
MSW443-3	-	2.5	3	4	-	-	-	-	-	-
W6234-4RUS	***3.0****	2.5	3	4	-	-	-	3.5	4	2
W8405-1R	-	2.5	3	4	-	-	-	-	-	-
MST065-1	-	2.6	3	4	-	-	-	-	-	-
MSW078-1	-	2.6	3	4	-	-	-	-	-	-

Table 7

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2010-2012 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER , MI

LINE	*3-YR* AVG.*	2012 RATING	2012 WORST	2012 N	2011 RATING	2011 WORST	2011 N	2010 RATING	2010 WORST	2010 N
Sorted by ascending 2012 Rating;										
MSW2717-5	-	2.6	4	4	-	-	-	-	-	-
Purple Heart	***2.4****	2.6	3	4	2.1	3	4	-	-	-
Snowden	***2.6***	**2.6**	**3**	**8**	**2.4**	**3**	**4**	**2.9**	**4**	**10**
W5015-12	***2.8****	2.6	3	4	-	-	-	3.0	4	2
CO02321-4W	***2.9****	2.8	3	4	-	-	-	3.0	3	2
MN02586	***3.0****	2.8	3	4	3.3	4	2	-	-	-
MSM288-2Y	***2.9***	2.8	3	4	3.0	3	4	3.0	3	2
MSR217-1R	***2.5***	2.8	4	4	2.8	3	4	2.0	2	1
MST020-2Y	-	2.8	4	4	-	-	-	-	-	-
NY140	***2.6****	2.8	3	4	2.5	3	4	-	-	-
Atlantic	***2.9***	**2.8**	**4**	**12**	**3.0**	**4**	**11**	**2.9**	**3**	**10**
MN02419	-	2.9	4	4	-	-	-	-	-	-
MSR216-AP	-	2.9	3	4	-	-	-	-	-	-
MSS934-4	-	2.9	4	4	-	-	-	-	-	-
MSW182-1Y	-	2.9	4	4	-	-	-	-	-	-
MSW316-3PY	-	2.9	4	4	-	-	-	-	-	-
NorValley	***2.5***	3.0	4	4	2.3	3	4	2.3	3	2
Yukon Gold	***3.0****	**3.0**	**3**	**4**	**3.0**	**4**	**4**	-	-	-
CF7523-1	-	3.1	4	4	-	-	-	-	-	-
MSW453-1P	-	3.1	4	4	-	-	-	-	-	-
ND08305-1	-	3.1	4	4	-	-	-	-	-	-
Red Pontiac	***3.8***	**3.4**	**4**	**4**	**3.4**	**4**	**4**	**4.5**	**5**	**2**
MSM409-2Y	-	3.5	5	4	-	-	-	-	-	-
AC00206-2W	-	3.8	5	4	-	-	-	-	-	-
$HSD_{0.05}$ =		**1.4**			**1.5**			**2.3**		

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 Clarkston Research Center.

N = Number of replications.

*2-Year Average.

Table 8

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2012 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
2XLB-017	4	1.9
2XLB-031	2	0.4
2XLB-060	3	1.8
2XLB-075	3	0.4
2XLB-090	3	3.7
2XLB-119	3	0.4
A01124-3RUS	2	12.4
A02062-ITE	2	11.6
AF3362-1RUS	3	21.9
AND00618-2RUS	3	7.3
ARS10215-1	3	1.9
Atlantic	15	24.1
BER141	3	4.8
BER63	3	4.7
BER83	3	0.9
BP79.9	3	4.5
C002321-4W	3	33.4
C003187-1RUS	3	26.5
C003276-4RUS	3	12.5
C003276-5RUS	3	21.6
C004159-1R	3	20.1
C004211-4RUS	3	23.1
C004220-7RUS	3	26.0
C004233-1RUS	3	6.6
Dakotah Trailblazer	3	2.2
Dk Red Norland	3	32.7
FL1879	3	19.7
Goldrush	3	15.6
HS66	3	31.0
J138-K6A22	3	2.7
Jacqueline Lee	3	7.1
Kerrs Pink	3	1.3
Kufri Jeevan	3	5.0
Lamoka	3	13.5
LBR9	3	13.7
Lucky Joe	3	3.5
MCR125	3	9.7
MCR140	3	2.2
Missaukee	3	3.7
MN02419	3	3.5
MN02467	3	5.2
MN02586	3	17.6
MN04844-01	3	5.9
MN18747	3	27.3
MSJ042-3	3	8.1
MSK049-1	3	1.7

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
VSB18386056.17	2	0.4		
2XLB-031	2	0.4		
2XLB-075	3	0.4		
2XLB-119	3	0.4		
VSB19389349.1	3	0.5		
VSB16LBR8	4	0.8		
Stirling	3	0.8		
MSM182-2	4	0.8	Stirling	NY121
BER83	3	0.9		
MSK136-2	3	0.9		
MSS810-23	3	1.0	JacLee	Mcr1-205
MSS806-7	3	1.0	Atlantic	Mcr1-205
MSR093-4	2	1.1	Torridon	OP
MSS818-4	3	1.2	Stirling	Mcr1-205
Kerrs Pink	3	1.3		
NY148	3	1.4		
MSS487-2	3	1.5	STIRLING	J461-1
MSK049-1	3	1.7	Brodick	H192-2
MSM183-1	2	1.8	Torridon	Jac Lee
2XLB-060	3	1.8		
VSB2186F-302-8	3	1.8		
2XLB-017	4	1.9		
ARS10215-1	3	1.9		
MSQ176-5	6	2.1	I152-A	Missuakee
Dakotah Trailblazer	3	2.2		
MCR140	3	2.2		
MSW168-2	3	2.5	Beacon Chipper	R159-2
NY140	3	2.6		
J138-K6A22	3	2.7	S. blb	
ND039036-2R	3	2.7		
MSS826-4	3	2.8	Mcr1-140	Ber2-83
MSW229-5P	3	3.0	MI Purple	N105-1
Torridon	3	3.3		
MSQ492-2	3	3.4	Pike	J461-1
Lucky Joe	3	3.5		
MN02419	3	3.5		
MSW100-1	3	3.5	LBR9	P292-7
MSW464-3	3	3.5	M246-B	R102-3
2XLB-090	3	3.7		
Missaukee	3	3.7		
MSW324-1	3	3.7	Q070-1	Marcy
MSW360-18	3	3.7	R061-1	N238-A
MSL268-D	3	4.0	Eva	J. Lee
MSW485-2	3	4.1	Q070-1	R156-7
MSW259-6	3	4.1	N073-2	R159-2
Russet Norkotah LT	3	4.2		

2012 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSK136-2	3	0.9
MSL211-3	6	22.0
MSL268-D	3	4.0
MSM171-A	3	10.4
MSM182-2	4	0.8
MSM183-1	2	1.8
MSM409-2Y	2	5.5
MSP516-A	3	5.9
MSQ035-3	2	13.6
MSQ086-3	3	18.9
MSQ089-1	3	10.0
MSQ131-A	3	13.4
MSQ176-5	6	2.1
MSQ440-2	3	15.8
MSQ492-2	3	3.4
MSR054-7	4	7.8
MSR058-1	3	5.2
MSR061-1	3	5.7
MSR093-4	2	1.1
MSR161-2	3	4.4
MSR214-2P	3	15.7
MSR216-AP	3	14.9
MSR217-1R	3	7.7
MSS165-2Y	3	6.1
MSS206-2	3	9.1
MSS483-1	3	8.1
MSS487-2	3	1.5
MSS576-05SPL	3	13.4
MSS582-2SPL	3	18.1
MSS805-8	3	4.6
MSS806-7	3	1.0
MSS810-23	3	1.0
MSS818-4	3	1.2
MSS826-4	3	2.8
MSS827-2	3	13.5
MSS927-1	3	16.2
MSS934-4	3	4.4
MST020-2Y	3	8.5
MST065-1	3	10.2
MST235-5SPL	5	5.4
MST412-3	3	6.4
MST611-1	3	7.6
MSW027-1	3	7.9
MSW078-1	3	7.7
MSW100-1	3	3.5
MSW121-5R	3	18.9
MSW122-9	3	25.5
MSW123-3	3	19.5

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
W6703-1Y	3	4.2		
MSS934-4	3	4.4	ND6095-1	ND7377Cb-1
MSR161-2	3	4.4	Stirling	J126-9Y
W6703-5Y	3	4.5		
BP79.9	3	4.5		
MSS805-8	3	4.6	Atlantic	Mcr1-150
BER63	3	4.7		
BER141	3	4.8		
MSW437-9	3	5.0	Boulder	R036-5
Kufri Jeevan	3	5.0		
MSW151-9	3	5.2	Montanosa	L211-3
MN02467	3	5.2		
MSR058-1	3	5.2	W1201	J319-1
Norwis	3	5.3		
MST235-5SPL	5	5.4	K128-A	N188-1
MSM409-2Y	2	5.5	J456-4	J365-6
MSR061-1	3	5.7	W1201	NY121
MN04844-01	3	5.9		
MSP516-A	3	5.9	Pike	Missaukee
MSS165-2Y	3	6.1	M188-1	L159-AY
MST412-3	3	6.4	N105-1	M051-3
C004233-1RUS	3	6.6		
W7449-1RUS	3	6.8		
MSW153-1	3	6.8	1989-86061	I152-A
MSW140-3	3	6.9	MegaChip	J461-1
Jacqueline Lee	3	7.1	Tollocan	Chaleur
Rus Burbank	3	7.2		
AND00618-2RUS	3	7.3		
MST611-1	3	7.6		
MSW078-1	3	7.7	K409-1	Malinche
MSR217-1R	3	7.7	NDTX4271-5R	J461-1
MSR054-7	4	7.8	Pike	J461-1
MSW027-1	3	7.9	Eva	Q176-5
MSW410-12Y	3	8.0	E69.6	N105-1
MSJ042-3	3	8.1	BRODICK	ZAREVO
MSS483-1	3	8.1	M171-A	J461-1
MSW453-1P	3	8.2	Kenya Baraka	N215-2P
Rus Norkotah	3	8.4		
MST020-2Y	3	8.5	ARS4070-16Y	G004-3
MSS206-2	3	9.1	UEC	J461-1
MCR125	3	9.7		
Red Pontiac	3	9.9		
MSQ089-1	3	10.0	A91790-13	Missuakee
MST065-1	3	10.2	Boulder	L211-3
MSM171-A	3	10.4	Stirling	MSE221-1
MSW500-4	3	10.5	Boulder	P516-A
NY150	3	10.7		
MSW316-3PY	3	11.0		

2012 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSW125-3	3	19.6
MSW128-2	3	14.4
MSW140-3	3	6.9
MSW148-1P	3	20.0
MSW151-9	3	5.2
MSW153-1	3	6.8
MSW168-2	3	2.5
MSW229-5P	3	3.0
MSW252-2	3	14.4
MSW259-6	3	4.1
MSW270-1	3	16.8
MSW2717-5	3	22.2
MSW273-3R	3	21.1
MSW298-4Y	3	19.6
MSW316-3PY	3	11.0
MSW324-1	3	3.7
MSW326-6	3	11.7
MSW343-2R	3	18.1
MSW360-18	3	3.7
MSW410-12Y	3	8.0
MSW437-9	3	5.0
MSW453-1P	3	8.2
MSW464-3	3	3.5
MSW474-1	3	12.0
MSW476-4R	3	15.3
MSW485-2	3	4.1
MSW500-4	3	10.5
ND039036-2R	3	2.7
ND08305-1	3	20.7
ND7519-1	3	21.2
ND8068-5RUS	2	32.0
NorValley	3	26.1
Norwis	3	5.3
NY140	3	2.6
NY148	3	1.4
NY150	3	10.7
Onaway	6	29.2
Pike	6	22.9
Purple Heart	3	21.8
Reba	2	29.2
Red Pontiac	3	9.9
Rus Burbank	3	7.2
Rus Norkotah	3	8.4
Russet Norkotah LT	3	4.2
Russet Norkotah TX22	3	16.0
Silverton	3	11.9
Snowden	11	15.8
Stirling	3	0.8

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
A02062-ITE	2	11.6		
MSW326-6	3	11.7	Q070-1	N190-2
W5015-12	3	11.9		
Silverton	3	11.9		
MSW474-1	3	12.0	N190-2	P516-A
A01124-3RUS	2	12.4		
C003276-4RUS	3	12.5		
MSS576-05SPL	3	13.4	I005-20Y	L211-3
MSQ131-A	3	13.4	Boulder	Missuakee
Lamoka	3	13.5		
MSS827-2	3	13.5	Mcr1-140	Ber2-141
MSQ035-3	2	13.6	G227-2	Missaukee
LBR9	3	13.7		
W6511-1R	3	14.2		
MSW128-2	3	14.4	M171-A	Q176-5
MSW252-2	3	14.4	P516-A	OP
WV4298-1	3	14.7		
MSR216-AP	3	14.9	NDC5281-2R	J317-1
MSW476-4R	3	15.3	N230-6RY	NDTX4271-5R
Goldrush	3	15.6		
MSR214-2P	3	15.7	ND5084-3R	J317-1
Snowden	11	15.8		
MSQ440-2	3	15.8	K214-1R	Missaukee
Russet Norkotah TX22	3	16.0		
MSS927-1	3	16.2	ND4350-3	ND7799C-1
W6234-4RUS	3	16.6		
MSW270-1	3	16.8		
MN02586	3	17.6		
V1115-3	3	18.0		
MSW343-2R	3	18.1	Q440-2	NDTX4271-5R
MSS582-2SPL	3	18.1	L228-1	L211-3
V1588-1	3	18.1		
MSQ086-3	3	18.9	Onaway	Missaukee
MSW121-5R	3	18.9	M182-1	NDTX4271-5R
MSW123-3	3	19.5	M171-A	Dakota Diamond
MSW298-4Y	3	19.6	P408-10Y	L211-3
MSW125-3	3	19.6	M171-A	L211-3
FL1879	3	19.7		
MSW148-1P	3	20.0	MI Purple	P516-A
C004159-1R	3	20.1		
ND08305-1	3	20.7		
MSW273-3R	3	21.1	NDTX4271-5R	N105-1
ND7519-1	3	21.2		
Teton	2	21.5		
C003276-5RUS	3	21.6		
Purple Heart	3	21.8		
AF3362-1RUS	3	21.9		
MSL211-3	6	22.0	G301-9	J.Lee

2012 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
Teton	2	21.5
Torridon	3	3.3
V1115-3	3	18.0
V1588-1	3	18.1
VSB16LBR8	4	0.8
VSB18386056.17	2	0.4
VSB19389349.1	3	0.5
VSB2186F-302-8	3	1.8
W4980-1	3	24.6
W5015-12	3	11.9
W6002-1R	3	25.1
W6234-4RUS	3	16.6
W6511-1R	3	14.2
W6703-1Y	3	4.2
W6703-5Y	3	4.5
W7449-1RUS	3	6.8
W8405-1R	3	22.6
WV4298-1	3	14.7
WV4993-1	2	30.8
Yukon Gold	3	26.4

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
MSW2717-5	3	22.2		
W8405-1R	3	22.6		
Pike	6	22.9		
C004211-4RUS	3	23.1		
Atlantic	15	24.1		
W4980-1	3	24.6		
W6002-1R	3	25.1		
MSW122-9	3	25.5	M185-1	P085-2
C004220-7RUS	3	26.0		
NorValley	3	26.1		
Yukon Gold	3	26.4		
C003187-1RUS	3	26.5		
MN18747	3	27.3		
Onaway	6	29.2		
Reba	2	29.2		
WV4993-1	2	30.8		
HS66	3	31.0		
ND8068-5RUS	2	32.0		
Dk Red Norland	3	32.7		
C002321-4W	3	33.4		

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

Table 9

2012 NATIONAL LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
A01010-1	3	4.1
A02138-2	3	11.7
A02424-83LB	3	1.8
A02507-2LB	2	0.6
A03158-2TE	3	5.4
AC00395-2RU	3	0.8
AF3317-15	3	0.6
AF4122-3	3	0.7
AF4191-2	3	1.1
AF4329-7	3	10.0
AF4677-1	3	4.5
AND993G2B-1RUS	3	2.2
AWN86514-2	3	0.6
B0692-4	3	2.1
B0718-3	3	0.6
B2874-1	3	20.9
B2942-5	3	6.0
B2954-11	2	3.1
B2958-2	3	8.6
B2971-2	3	20.5
C002024-9W	3	5.6
C002033-1W	3	4.4
C002321-4W	3	19.6
LBR1	3	1.6
LBR2	3	5.0
LBR3	3	1.9
LBR4	3	3.3
LBR5	3	2.9
LBR7	3	2.1
MSP516-A	3	2.3
MSQ086-3	3	4.4
MSQ131-A	3	12.0
MSR061-1	3	1.1
MSR214-2P	3	7.1
ND071302B-2RUSS	3	30.9
ND071421CB-1RUS	3	20.2
ND081476B-1RUSS	3	10.2

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN
A02507-2LB	2	0.6
AF3317-15	3	0.6
B0718-3	3	0.6
AWN86514-2	3	0.6
AF4122-3	3	0.7
AC00395-2RU	3	0.8
AF4191-2	3	1.1
MSR061-1	3	1.1
LBR1	3	1.6
A02424-83LB	3	1.8
LBR3	3	1.9
B0692-4	3	2.1
LBR7	3	2.1
AND993G2B-1RUS	3	2.2
MSP516-A	3	2.3
LBR5	3	2.9
B2954-11	2	3.1
LBR4	3	3.3
A01010-1	3	4.1
C002033-1W	3	4.4
MSQ086-3	3	4.4
AF4677-1	3	4.5
LBR2	3	5.0
A03158-2TE	3	5.4
C002024-9W	3	5.6
B2942-5	3	6.0
MSR214-2P	3	7.1
B2958-2	3	8.6
AF4329-7	3	10.0
ND081476B-1RUSS	3	10.2
A02138-2	3	11.7
MSQ131-A	3	12.0
C002321-4W	3	19.6
ND071421CB-1RUS	3	20.2
B2971-2	3	20.5
B2874-1	3	20.9
ND071302B-2RUSS	3	30.9

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

Table 10

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2012 LATE BLIGHT EARLY GENERATION TRIALS
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSV179-6	EG	5.7
MSW027-1	EG	19.8
MSW078-1	EG	1.3
MSW100-1	EG	0.7
MSW119-2	EG	5.1
MSW121-5R	EG	12.1
MSW122-9	EG	18.3
MSW123-3	EG	28.9
MSW125-3	EG	25.1
MSW128-2	EG	1.7
MSW140-3	EG	7.3
MSW148-1P	EG	7.9
MSW151-9	EG	2.2
MSW153-1	EG	3.1
MSW154-4	EG	7.4
MSW163-3	EG	9.3
MSW168-2	EG	1.3
MSW206-2P	EG	2.2
MSW229-5P	EG	0.5
MSW252-2	EG	11.5
MSW259-5	EG	15.1
MSW259-6	EG	8.6
MSW273-3R	EG	18.7
MSW298-4Y	EG	21.7
MSW324-1	EG	3.0
MSW326-6	EG	14.6
MSW343-2R	EG	25.7
MSW360-18	EG	1.5
MSW410-12Y	EG	14.8
MSW418-1	EG	6.9
MSW432-13	EG	17.9
MSW437-9	EG	9.9
MSW453-1P	EG	6.2
MSW455-3	EG	4.7
MSW464-3	EG	1.4
MSW474-1	EG	3.3
MSW476-4R	EG	11.8
MSW485-2	EG	1.4
MSW500-4	EG	3.3
MSW536-2P	EG	1.6
MSW537-6	EG	0.7
MSX001-4WP	EG	0.4
MSX001-7WP	EG	1.5
MSX001-9	EG	ND
MSX009-2	EG	6.5
MSX010-3	EG	23.8
MSX016-4	EG	6.2

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
MSX452-1	EG	0.0	Q070-1	Atlantic
MSX502-2	EG	0.0	Q176-5	L211-3
MSX510-1	EG	0.1	Q289-1	J461-1
MSX361-1	EG	0.2	N251-1Y	Q134-5
MSX517-3	EG	0.2	Q425-4YSPL	Q176-5
MSX496-2	EG	0.3	Q131-A	L211-3
MSX001-4WP	EG	0.4	ARS10091WP	L211-3
MSX375-4R	EG	0.4	NDTX4271-5R	R160-2Y
MSX271-6R	EG	0.4	M182-1	NDTX4271-5R
MSX295-1Y	EG	0.4	M288-2Y	R160-2Y
MSX278-2	EG	0.4	M246-B	J461-1
MSX198-5	EG	0.5	J461-1	OP
MSW229-5P	EG	0.5	MI Purple	N105-1
MSX199-1	EG	0.5	J461-1	W2133-1
MSX221-1	EG	0.5	K061-4	R036-5
MSX311-1	EG	0.5	MegaChip	R036-5
MSX354-1P	EG	0.5	N215-2P	NY121
MSX367-2	EG	0.5	ND8307C-3	R061-1
MSX373-9R	EG	0.5	NDTX4271-5R	NY121
MSX540-4	EG	0.5	R061-1	NY139
MSX489-2	EG	0.6	Q070-1	W2133-1
MSX517-1Y	EG	0.6	Q425-4YSPL	Q176-5
MSW100-1	EG	0.7	LBR9	P292-7
MSW537-6	EG	0.7	M070-1	P516-A
MSX538-1	EG	0.7	R061-1	J461-1
MSX669-2	EG	0.7	W2310-3	R041-3
MSX270-2P	EG	0.8	M182-1	N215-2P
MSX075-3	EG	0.8	Boulder	Stirling
MSX507-1R	EG	0.8	Q176-5	R219-2R
MSX654-2	EG	0.8	Torridon	L211-3
MSX542-2	EG	0.8	R102-3	Megachip
MSX506-3Y	EG	0.9	Q176-5	R169-8Y
MSX566-1	EG	0.9	Reba	Q176-5
MSX650-3	EG	1.0	Stirling	L211-3
MSX271-5R	EG	1.0	M182-1	NDTX4271-5R
MSX196-3	EG	1.0	J461-1	L292-A
MSX628-1	EG	1.1	S927-1	L211-3
MSX136-1	EG	1.1	Eva	J461-1
MSX398-2	EG	1.1	NY139	Stirling
MSX472-1	EG	1.2	Q070-1	P292-7
MSX493-5	EG	1.2	Q089-1	S026-2Y
MSW078-1	EG	1.3	K409-1	Malinche
MSW168-2	EG	1.3	Beacon Chipper	R159-2
MSW464-3	EG	1.4	M246-B	R102-3
MSW485-2	EG	1.4	Q070-1	R156-7
MSX142-2	EG	1.5	Eva	Q176-5
MSX292-4Y	EG	1.5	M288-2Y	Q134-5

2012 LATE BLIGHT EARLY GENERATION TRIALS
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSX016-9	EG	1.7
MSX028-2	EG	1.8
MSX033-1	EG	9.8
MSX048-1	EG	2.6
MSX066-3	EG	1.5
MSX071-1	EG	3.3
MSX075-3	EG	0.8
MSX136-1	EG	1.1
MSX137-3	EG	4.8
MSX137-6	EG	13.8
MSX142-2	EG	1.5
MSX159-1Y	EG	8.8
MSX189-2	EG	6.3
MSX194-3	EG	2.1
MSX196-1	EG	7.9
MSX196-3	EG	1.0
MSX196-4	EG	1.9
MSX196-5	EG	9.0
MSX198-5	EG	0.5
MSX199-1	EG	0.5
MSX199-3	EG	6.5
MSX220-2	EG	ND
MSX221-1	EG	0.5
MSX255-1	EG	4.1
MSX261-1	EG	11.0
MSX263-1R	EG	37.4
MSX267-1	EG	3.9
MSX268-3Y	EG	13.3
MSX270-2P	EG	0.8
MSX271-1R	EG	2.0
MSX271-5R	EG	1.0
MSX271-6R	EG	0.4
MSX273-1	EG	2.6
MSX278-1	EG	7.3
MSX278-2	EG	0.4
MSX286-5Y	EG	13.1
MSX292-4Y	EG	1.5
MSX293-1Y	EG	ND
MSX295-1Y	EG	0.4
MSX296-1Y	EG	15.9
MSX306-1	EG	1.8
MSX311-1	EG	0.5
MSX319-1	EG	12.0
MSX322-1Y	EG	9.9
MSX322-3Y	EG	ND
MSX324-1P	EG	2.9
MSX326-3	EG	3.1
MSX327-1	EG	9.9
MSX342-2	EG	14.8
MSX351-3P	EG	14.7

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
MSX066-3	EG	1.5	Boulder	Q086-3
MSW360-18	EG	1.5	R061-1	N238-A
MSX001-7WP	EG	1.5	ARS10091WP	L211-3
MSW536-2P	EG	1.6	MI Purple Red Sport	N105-1
MSW128-2	EG	1.7	M171-A	Q176-5
MSX413-2	EG	1.7	Q086-3	OP
MSX016-9	EG	1.7	ARS10342-4	L211-3
MSX028-2	EG	1.8	Atlantic	R036-5
MSX306-1	EG	1.8	MegaChip	NY121
MSX196-4	EG	1.9	J461-1	L292-A
MSX271-1R	EG	2.0	M182-1	NDTX4271-5R
MSX194-3	EG	2.1	J461-1	C095051-7W
MSX534-2	EG	2.1	R041-3	NY139
MSW151-9	EG	2.2	Montanosa	L211-3
MSW206-2P	EG	2.2	LBR9	N215-2P
MSX491-1	EG	2.2	Q089-1	J126-9Y
MSX466-1	EG	2.2	Q070-1	NY121
MSX273-1	EG	2.6	M182-1	Q134-5
MSX389-2	EG	2.6	NY139	L268-D
MSX048-1	EG	2.6	Beacon Chipper	R036-5
MSX547-3	EG	2.7	R160-2Y	Megachip
MSX467-1	EG	2.9	Q070-1	NY139
MSX324-1P	EG	2.9	N105-1	N215-2P
MSX629-3	EG	3.0	S927-1	Q176-5
MSX509-4	EG	3.0	Q279-1	L211-3
MSW324-1	EG	3.0	Q070-1	Marcy
MSW153-1	EG	3.1	1989-86061	I152-A
MSX326-3	EG	3.1	N105-1	NY121
MSW474-1	EG	3.3	N190-2	P516-A
MSW500-4	EG	3.3	Boulder	P516-A
MSX071-1	EG	3.3	Boulder	R036-5
MSX469-2	EG	3.8	Q070-1	OP
MSX649-1	EG	3.8	Stirling	J126-9Y
MSX267-1	EG	3.9	M182-1	L211-3
MSX354-2	EG	4.0	N215-2P	NY121
MSX255-1	EG	4.1	M171-A	ARS10342-4
MSX596-1	EG	4.3	S097-3	NY139
MSX458-1	EG	4.5	Q070-1	Kalkaska
MSW455-3	EG	4.7	L183-AY	P516-A
MSX137-3	EG	4.8	Eva	L211-3
MSW119-2	EG	5.1	M171-A	R036-5
MSX592-2	EG	5.4	S097-3	CO95051-7W
MSV179-6	EG	5.7	LBR8	L211-3
MSW453-1P	EG	6.2	Kenya Baraka	N215-2P
MSX016-4	EG	6.2	ARS10342-4	L211-3
MSX189-2	EG	6.3	J147-1	R036-5
MSX199-3	EG	6.5	J461-1	W2133-1
MSX009-2	EG	6.5	ARS10241-2	J461-1
MSW418-1	EG	6.9	RB G227-2	J319-1
MSX278-1	EG	7.3	M246-B	J461-1

2012 LATE BLIGHT EARLY GENERATION TRIALS
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSX351-4P	EG	11.3
MSX354-1P	EG	0.5
MSX354-2	EG	4.0
MSX361-1	EG	0.2
MSX365-2	EG	8.5
MSX367-2	EG	0.5
MSX373-6R	EG	ND
MSX373-9R	EG	0.5
MSX375-2R	EG	ND
MSX375-4R	EG	0.4
MSX380-3	EG	12.4
MSX389-2	EG	2.6
MSX393-1	EG	20.6
MSX398-2	EG	1.1
MSX413-2	EG	1.7
MSX452-1	EG	0.0
MSX458-1	EG	4.5
MSX466-1	EG	2.2
MSX467-1	EG	2.9
MSX469-2	EG	3.8
MSX472-1	EG	1.2
MSX472-2	EG	9.6
MSX473-3	EG	9.6
MSX489-2	EG	0.6
MSX491-1	EG	2.2
MSX493-5	EG	1.2
MSX495-2	EG	ND
MSX496-2	EG	0.3
MSX497-8	EG	7.3
MSX502-2	EG	0.0
MSX503-5	EG	9.7
MSX506-3Y	EG	0.9
MSX507-1R	EG	0.8
MSX509-4	EG	3.0
MSX510-1	EG	0.1
MSX517-1Y	EG	0.6
MSX517-3	EG	0.2
MSX517-5Y	EG	14.7
MSX526-1	EG	ND
MSX534-2	EG	2.1
MSX538-1	EG	0.7
MSX540-4	EG	0.5
MSX542-2	EG	0.8
MSX547-3	EG	2.7
MSX566-1	EG	0.9
MSX592-2	EG	5.4
MSX596-1	EG	4.3
MSX615-1	EG	8.4
MSX620-5	EG	ND
MSX628-1	EG	1.1

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
MSX497-8	EG	7.3	Q131-A	L268-D
MSW140-3	EG	7.3	MegaChip	J461-1
MSW154-4	EG	7.4	1989-86061	L211-3
MSW148-1P	EG	7.9	MI Purple	P516-A
MSX196-1	EG	7.9	J461-1	L292-A
MSX615-1	EG	8.4	S419-8	Pike
MSX365-2	EG	8.5	ND8307C-3	J461-1
MSW259-6	EG	8.6	N073-2	R159-2
MSX159-1Y	EG	8.8	I005-20Y	NY121
MSX196-5	EG	9.0	J461-1	L292-A
MSW163-3	EG	9.3	Atlantic	R036-5
MSX472-2	EG	9.6	Q070-1	P292-7
MSX473-3	EG	9.6	Q070-1	P459-5
MSX503-5	EG	9.7	Q176-5	L268-D
MSX033-1	EG	9.8	Atlantic	S176-1
MSX327-1	EG	9.9	N105-1	Q134-5
MSW437-9	EG	9.9	Boulder	R036-5
MSX322-1Y	EG	9.9	N105-1	M288-2Y
MSX261-1	EG	11.0	M171-A	Q176-5
MSX351-4P	EG	11.3	N215-2P	L211-3
MSW252-2	EG	11.5	P516-A	OP
MSW476-4R	EG	11.8	N230-6RY	NDTX4271-5R
MSX319-1	EG	12.0	N105-1	ARS10241-2
MSW121-5R	EG	12.1	M182-1	NDTX4271-5R
MSX380-3	EG	12.4	NY121	M246-B
MSX286-5Y	EG	13.1	M288-2Y	L211-3
MSX268-3Y	EG	13.3	M182-1	L268-D
MSX137-6	EG	13.8	Eva	L211-3
MSW326-6	EG	14.6	Q070-1	N190-2
MSX517-5Y	EG	14.7	Q425-4YSPL	Q176-5
MSX351-3P	EG	14.7	N215-2P	L211-3
MSX342-2	EG	14.8	N170-A	R036-5
MSW410-12Y	EG	14.8	E69.6	N105-1
MSW259-5	EG	15.1	N073-2	R159-2
MSX296-1Y	EG	15.9	M288-2Y	S165-2Y
MSW432-13	EG	17.9	Boulder	I152-A
MSW122-9	EG	18.3	M185-1	P085-2
MSW273-3R	EG	18.7	NDTX4271-5R	N105-1
MSW027-1	EG	19.8	Eva	Q176-5
MSX393-1	EG	20.6	NY139	N191-2Y
MSW298-4Y	EG	21.7	P408-10Y	L211-3
MSX010-3	EG	23.8	ARS10241-2	L211-3
MSW125-3	EG	25.1	M171-A	L211-3
MSW343-2R	EG	25.7	Q440-2	NDTX4271-5R
MSW123-3	EG	28.9	M171-A	Dakota Diamond
MSX263-1R	EG	37.4	M171-A	R219-2R
MSX001-9	EG	ND	ARS10091WP	L211-3
MSX220-2	EG	ND	K061-4	Q176-5
MSX293-1Y	EG	ND	M288-2Y	Q176-5
MSX322-3Y	EG	ND	N105-1	M288-2Y

2012 LATE BLIGHT EARLY GENERATION TRIALS
CLARKSVILLE RESEARCH CENTER, MI

Line Sort:

LINE	N	RAUDPC[1] MEAN
MSX629-3	EG	3.0
MSX649-1	EG	3.8
MSX650-3	EG	1.0
MSX654-2	EG	0.8
MSX669-2	EG	0.7

RAUDPC Sort:

LINE	N	RAUDPC[1] MEAN	Female	Male
MSX373-6R	EG	ND	NDTX4271-5R	NY121
MSX375-2R	EG	ND	NDTX4271-5R	R160-2Y
MSX495-2	EG	ND	Q131-A	Kalkaska
MSX526-1	EG	ND	R036-5	NY139
MSX620-5	EG	ND	S582-1SPL	NDTX4271-5R

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

Table 11

2012 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	SP GR	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ADVANCED and CHIP-PROCESSING TRIAL									
MSR148-4	1.065	21	4					84	0.2
Pike	**1.079**	**15**	**7**	**3**				**60**	**0.5**
MSJ126-9Y	1.075	12	11	2				48	0.6
MSQ131-A	1.067	14	7	4				56	0.6
MSQ440-2	1.057	13	9	3				52	0.6
MSS206-2	1.063	15	6	3	1			60	0.6
AC00206-2W	1.074	13	6	6				52	0.7
MSQ089-1	1.070	11	10	4				44	0.7
MSR128-4Y	1.083	10	11	3	1			40	0.8
AC03452-2W	1.068	5	15	3	2			20	1.1
MSL292-A	1.077	10	7	5	2	1		40	1.1
MSQ279-1	1.072	7	12	3	2	1		28	1.1
MSR061-1	1.076	8	9	4	2		2	32	1.3
CO02321-4W	1.078	4	12	6	2		1	16	1.4
Snowden	**1.080**	**1**	**14**	**8**	**2**			**4**	**1.4**
MSR169-8Y	1.077	6	6	6	7			24	1.6
MSL007-B	1.078	5	8	5	5	1	1	20	1.7
FL1879	**1.074**	**6**	**3**	**10**	**5**		**1**	**24**	**1.7**
Atlantic	**1.084**	**6**	**5**	**7**	**4**	**2**	**1**	**24**	**1.8**
MSQ086-3	1.074	4	9	5	3	4		16	1.8
NY140	1.077	2	12	5	2	2	2	8	1.8
MSP270-1	1.069	1	8	10	7			4	1.9
Lamoka	1.080	4	5	8	4	1	2	17	2.0
MSN190-2	1.090	3	4	9	5	2	1	13	2.1
MSS165-2Y	1.085	2	3	13	2	4	1	8	2.2
MSR127-2	1.084	2	6	6	5	3	2	8	2.3
W4980-1	1.077	1	5	8	2	5	4	4	2.7
NY148	1.093	0	2	4	10	4	5	0	3.2
MSQ035-3	1.078	0	1	1	5	6	12	0	4.1
MSP516-A	1.074	1		1	2	4	16	4	4.3
RUSSET TRIAL									
CO04159-1RY	1.056	21	2					91	0.1
CO04233-1Rus	1.062	20	5					80	0.2
AF3362-1Rus	1.067	19	5					79	0.2
A01124-3Rus	1.072	15	8	2				60	0.5
Russet Burbank	**1.067**	**15**	**7**	**1**		**1**		**63**	**0.5**
W7449-1Rus	1.077	13	7	1	1			59	0.5

Table 11

2012 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	SP GR	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
Russet Norkotah	**1.065**	**13**	**9**	**3**				**52**	**0.6**
AND00618-2RussY	1.077	13	8	4				52	0.6
Silverton Russet	1.064	12	11	1	1			48	0.6
A02062-1TE	1.065	13	7	5				52	0.7
Teton Russet	1.064	11	9	4				46	0.7
CO04220-7Rus	1.065	11	9	5				44	0.8
CO04211-4Rus	1.066	12	12		3			44	0.8
Russet Norkotah LT	1.066	13	7	2	3			52	0.8
GoldRush Russet	**1.061**	**10**	**9**	**5**	**1**			**40**	**0.9**
Russet Norkotah TX223	1.064	10	9	4	2			40	0.9
W6234-4Rus	1.077	4	15	4	2			16	1.2
Dakota Trailblazer	1.089	4	9	3	4	2	1	17	1.7
ND8068-5Rus	1.071	4	6	7	4	3	1	16	2.0
CO03187-1Rus	1.072	5	4	5	8	1	2	20	2.1
CO03276-4Rus	1.069							nd	nd
CO03276-5Rus	1.069							nd	nd
NORTH CENTRAL REGIONAL TRIAL									
W6002-1R	1.052	21	4					84	0.2
Dk. Red Norland	**1.083**	**18**	**5**	**1**				**75**	**0.3**
MN18747	1.058	18	5	1				75	0.3
MN02586	1.066	15	5	2	2	1		60	0.8
MN04844-01	1.072	11	10	3	1			44	0.8
W2717-5 (Lelah)	1.084	8	10	6	1			32	1.0
W8405-1R	1.056	9	10	2	2	1		38	1.0
Red Pontiac	**1.055**	**7**	**9**	**5**	**4**			**28**	**1.2**
Snowden	**1.077**	**5**	**9**	**9**	**1**	**1**		**20**	**1.4**
ND7519-1	1.079	5	6	6	2	1		25	1.4
W5015-12	1.081	5	6	7	5	1		21	1.6
MN02419	1.078	4	4	11	4	2		16	1.8
MN02467 (19 tubers)	1.076	4	5	5	2	1	2	21	1.8
Atlantic	**1.082**	**3**	**6**	**8**	**5**	**1**	**2**	**12**	**2.0**
NorValley	1.070	1	3	8	8	1	3	4	2.6
ND8305-1	1.082	1	2	8	6		5	5	2.8
ADAPTATION TRIAL, TABLESTOCK LINES									
MSM288-2Y	1.068	25						100	0.0
NY150 (very small tubers)	1.071	24	1					96	0.0
Red Norland	**1.057**	**21**	**1**					**95**	**0.0**

Table 11

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2012 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	SP GR	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
Yukon Gold	**1.061**	**20**	**1**				**1**	**91**	**0.3**
MSR214-2P	1.064	19	5	1				76	0.3
MSQ176-5	1.061	17	7	1				68	0.4
MSS582-2SPL	1.090	16	5	1		1		70	0.5
MSS544-1R	1.057	15	9		1			60	0.5
NorWis	1.066	13	9	2		1		52	0.7
MSL211-3	1.066	13	8	2	2			52	0.7
Purple Haze	1.070	12	7	4	1			50	0.8
Spartan Splash	1.068	13	7	4			1	52	0.8
MSR217-1R	1.053	9	12	3	1			36	0.8
MSS576-05SPL	1.072	9	12	2	2			36	0.9
Michigan Purple	1.067	9	11	3	2			36	0.9
Onaway	**1.059**	**7**	**13**	**3**		**1**		**29**	**1.0**
MSQ341-BY	1.071	13	4	3	2	2		54	1.0
Reba	**1.070**	**10**	**7**	**4**	**2**	**1**	**1**	**40**	**1.2**
Purple Heart	1.058	4	10	6	2		1	17	1.4
MSE149-5Y	1.066	4	9	7	1	2	1	17	1.6
MSR216-AP	1.070	3	6	7	2	3	4	12	2.3
PRELIMINARY TRIAL, CHIP-PROCESSING LINES									
MSW436-24	1.076	22	1	1				92	0.1
MSR054-7	1.072	20	5					80	0.2
MST096-2Y	1.068	22	2		1			88	0.2
MSW464-3	1.080	20	4		1			80	0.3
MSW485-2	1.089	18	5	2				72	0.4
MSQ492-2	1.073	18	6	2				69	0.4
MSW437-9	1.064	16	8	1				64	0.4
MSW138-2	1.077	16	8	2				62	0.5
MSS934-4	1.081	16	7	1	1			64	0.5
MSW360-18	1.075	14	10	1				56	0.5
MSS297-3	1.075	14	8	3				56	0.6
Pike	**1.075**	**12**	**11**	**2**				**48**	**0.6**
MST184-3	1.078	12	10	2	1			48	0.7
MSW075-1	1.076	8	16	1				32	0.7
MST096-4	1.068	14	5	4	2			56	0.8
MST412-3	1.076	14	6	4	1	1		54	0.8
MST441-1	1.077	13	7	2	2	1		52	0.8
MSW259-6	1.081	11	9	2	2	1		44	0.9
Snowden	**1.075**	**9**	**9**	**6**	**1**			**36**	**1.0**

Table 11

2012 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

ENTRY	SP GR	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
Atlantic	**1.081**	**9**	**9**	**3**	**1**	**3**		**36**	**1.2**
MSW168-2	1.082	9	5	8	3			36	1.2
MST424-3	1.074	2	5	9	6	1	1	8	2.1
MSW443-3	1.079	3	7	3	4	4	4	12	2.4
MSW140-3	1.085	1	8	5	3	2	5	4	2.5
MSW509-5	1.073	2	4	8	3	3	5	8	2.6
MSW474-1	1.081	1	1	8	5	4	8	4	3.3
PRELIMINARY TRIAL, TABLESTOCK LINES									
MSW239-3	1.047	17	8					68	0.3
MSW128-2	1.062	18	5	1	1			72	0.4
MSW273-3R	1.063	16	6	4				62	0.5
MSW298-4Y	1.068	16	6		1	1		67	0.5
MSW121-5R	1.051	14	8	3				56	0.6
MSW125-3	1.054	11	10	3				46	0.7
MSW122-9	1.062	10	12	3				40	0.7
MSW151-9	1.071	11	9	3	2			44	0.8
W6703-5Y	1.070	8	12	4	1			32	0.9
MSW027-1	1.062	9	11	2	3			36	1.0
W6703-1Y	1.076	8	12	3	2			32	1.0
MST065-1	1.075	10	7	3	2	1		43	1.0
Onaway	**1.056**	**7**	**9**	**7**	**2**			**28**	**1.2**
MSR226-ARR	1.070	5	12	5	2			21	1.2
MST611-1 (19 tubers)	1.072	6	5	6	2			32	1.2
Reba	**1.067**	**8**	**7**	**6**	**4**			**32**	**1.2**
MSW500-4	1.075	4	13	3	3	1	1	16	1.5
MSW123-3	1.065	4	10	4	3	3		17	1.6
MSW182-1Y	1.078	4	7	6	5	2		17	1.8
MSS487-2	1.078	5	9	4	2	2	3	20	1.8
MSW153-1	1.074	6	6	4	4	3	2	24	1.9
CF7523-1	1.070	3	2	9	5	3	2	13	2.4
MSW148-1P	1.080	1	6	3	8	3	4	4	2.7
USPB/SFA TRIAL CHECK SAMPLES (Not bruised)									
AF4157-6	1.064	23	2					92	0.1
MSR061-1	1.071	23	2					92	0.1
W2978-3	1.059	23	2					92	0.1
W6483-5	1.059	23	2					92	0.1
CO00188-4W	1.062	22	3					88	0.1

2012 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

		NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	SP GR	0	1	2	3	4	5+	FREE	SPOTS/TUBER
MN99380-1Y	1.065	20	5					80	0.2
ND8304-2	1.058	20	5					80	0.2
W4980-1	1.064	20	5					80	0.2
MSL292-A	1.068	19	6					76	0.2
A01143-3C	1.075	20	3	2				80	0.3
CO00197-3W	1.067	19	5	1				76	0.3
CO02321-4W	1.073	18	6	1				72	0.3
Snowden	**1.070**	**17**	**7**	**1**				**68**	**0.4**
NY140	1.072	16	8	1				64	0.4
W5015-12	1.076	19	3	1	1	1		76	0.5
ND8305-1	1.075	12	12	1				48	0.6
Atlantic	**1.077**	**11**	**12**	**2**				**44**	**0.6**
NY148	1.083	8	7	5	5			32	1.3
USPB/SFA TRIAL BRUISE SAMPLES									
AF4157-6	1.064	20	5					80	0.2
CO00188-4W	1.062	21	2	2				84	0.2
W6483-5	1.059	19	5	1				76	0.3
CO00197-3W	1.067	15	10					60	0.4
W2978-3	1.059	16	8	1				64	0.4
A01143-3C	1.075	17	5	3				68	0.4
MSL292-A	1.068	14	10	1				56	0.5
CO02321-4W	1.073	16	5	4				64	0.5
ND8304-2	1.058	16	4	5				64	0.6
MSR061-1	1.071	12	11	1	1			48	0.6
MN99380-1Y	1.065	13	10		1	1		52	0.7
Snowden	**1.070**	**12**	**10**	**1**	**2**			**48**	**0.7**
W4980-1	1.064	8	15	1	1			32	0.8
NY140	1.072	5	6	7	5		2	20	1.8
Atlantic	**1.077**	**2**	**8**	**8**	**5**	**1**	**1**	**8**	1.9
W5015-12	1.076	1	8	3	10	2	1	4	2.3
ND8305-1	1.075	0	2	6	7	7	3	0	3.1
NY148	1.083	0	3	4	1	6	11	0	3.7

* Twenty to twenty-five A-size tuber samples were collected at harvest, held at 50 F at least 12 hours, and placed in a six-sided plywood drum and rotated ten times to produce simulated bruising. Samples were abrasive-peeled and scored 10/30/2012.

The table is presented in ascending order of average number of spots per tuber.

Funding: Federal Grant, MPIC and USPB/SFA

2012 On-Farm Potato Variety Trials

Chris Long, Dr. Dave Douches, Luke Steere, Dr. Doo-Hong Min (Upper Peninsula), Chris Kapp (Upper Peninsula) and James DeDecker (Rogers City)

Introduction

On-farm potato variety trials were conducted with 18 growers in 2012 at a total of 21 locations. Eleven 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. (St. Joseph), County Line Potato Farms, Inc. (Allegan), Main Farms (Montcalm), Sackett Potatoes (Mecosta), Michigan State University (MSU) Montcalm Research Center (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), Kitchen Farms, Inc. (Antrim), R & E Farms (Presque Isle), Horkey Bros. (Monroe), T.J.J. VanDamme Farms (Delta), Krummrey & Sons, Inc. (Ingham), Walther Farms, Inc. (St. Joseph) and Brian Williams Farms (Sanilac).

Procedure

There were six types of processing trials conducted this year. The first type contained 16 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. In-row seed spacing in each trial was 10 inches. The second type of processing trial, referred to as a "Select" trial, contained eight 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. (Gratiot and Montcalm Counties). The third type was a processing variety trial where each plot consisted of three, 34" wide rows which were 15' long. Only the center row was harvested for the yield evaluation from each of four replications. This trial was conducted at Walther Farms, Inc. (St. Joseph). At Walther's, 13 varieties were compared to the check varieties Snowden, Pike and FL1879. The plots were planted at 10" in-row seed spacing. The fourth type was the Box Bin trial at the Montcalm Research Center in Montcalm County, MI. This trial contained 14 varieties compared against the check variety Snowden. Each of the 15 varieties was planted in a single 34" wide row, 600' long with 10" in-row seed spacing. A single 23' yield check was taken to evaluate each clone. The fifth type of chip trial consisted of large multiple acreage blocks of three newly commercialized or soon to be commercialized varieties. Agronomic and production practices for these varieties were based on each individual grower's production system. The growers and varieties were: Sandyland Farms (Montcalm), MSJ126-9Y and MSL292-A; Sackett

Potatoes (Mecosta), Lamoka (NY139); Walther Farms (St. Joseph), Lamoka (NY139). The USPB / SFA chip trial was the sixth chip processing trial type. For procedural details on this trial, reference the 2012 annual report published by the United States Potato Board.

Within the fresh market trials, there were 39 entries evaluated. There were 3 to 26 lines planted in each of the following counties: Antrim, Delta, Ingham, Kalkaska, Monroe, Montcalm, Presque Isle, Sanilac, 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. The second fresh pack trial type was the Russet Select Trial. The select russet trials were planted at three locations (Elmaple Farm (Kalkaska), Montcalm Research Center (Montcalm) and Walther Farms, (St. Joseph)). At Elmaple Farms, each russet variety was planted in one, three row plot, that was thirty feet long with 34” wide rows and 11-12” in-row spacing. A yield determination was made on 23 feet of the center row. At Walther Farms, Inc. (St. Joseph), three row plots, replicated four times were evaluated. The plots were 15’ long by 34” wide and seed spacing was 12”. Only the center row was harvested and evaluated. 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 from ten locations across Allegan, Branch, Gratiot, Montcalm and St. Joseph counties are shown in Table 2. The varieties listed below in the highlights section are listed in yield and trial performance order highest to lowest. Not all varieties are listed.

Processing Variety Highlights

BNC182-5; this clone was crossed in North Carolina and selected in Beltsville, MD. BNC182-5 was the top overall yielding variety in the 2012 on-farm processing trials. In 2012, it yielded 529 cwt./A US#1 with 20 percent oversize tubers (Table 2). Seventeen percent of the oversize tubers were hollow. The specific gravity was slightly above the trial average at 1.073. The variety had a full season maturity at 120 days. The apical eyes were moderately deep on the larger tubers. Some SED was reported in the out of the field chip sample. The variety had a generally round to flattened appearance and expressed moderate common scab tolerance.

NY148 (NYE106-4); this Cornell University developed clone exhibited a strong yield, good size profile and common scab tolerance. In 2012, NY148 yielded 492 cwt./A US#1 over eight locations with an 88% marketable yield average (Table 2).

The specific gravity of this clone was ten points above the trial average at 1.081. Two hollow heart were noted in 110 cut tubers. Vine maturity for this variety appeared to be 120 to 130 days. Reports indicate that the chip quality of NY148 does not appear to be as good as Lamoka, but in 2012, NY148 chipped better than in 2011.

NY140; this is a Cornell University developed clone. This variety exhibits a strong yield and good tuber size profile. In the 2012 processing potato variety trials, this selection yielded 489 cwt./A US#1 over five locations with a 90% marketable yield average (Table 2). The specific gravity of this clone was three points below the trial average at 1.068. No tubers with hollow heart were noted in 80 cut tubers. Vine maturity for this variety appeared to be late. This variety shows some common scab susceptibility.

MSR127-2; this is an MSU clone with common scab tolerance. In 2012 on-farm trials, this variety yielded 449 cwt./A US#1 with a 1.074 specific gravity, which is three points above the trial average of 1.071. There were three tubers with hollow heart observed in 100 cut tubers (Table 2). This variety had a vine maturity that was similar to Snowden. Tuber type was uniform and round and chip quality was good from mid-season storage.

MSL007-B; this is an MSU selection with a heavy netted skin, uniform tuber type and common scab tolerance (Table 1). In 2012, it yielded above average at 437 cwt./A US#1 (Table 2). Chip quality appears to be good from mid-season storage, but some stem end defect has been observed in finished chips from various regions of the state.

AF4157-6; this selection has been developed at the University of Maine. This variety appears to chip process well from out-of-the-field and early to mid-season storage. It's yield potential was good, producing 425 cwt./A US#1 in 2012 (Table 2). The average specific gravity of this line was 1.069. No tubers with hollow heart were observed in 80 cut tubers. This line has some common scab susceptibility and appears to exhibit an early-season maturity.

Lamoka (NY139); this is a Cornell University developed clone. This variety continues to exhibit a strong yield and good size profile. In the 2012 processing potato variety trials, Lamoka yielded 422 cwt./A US#1 over nine locations with a 93% marketable yield average (Table 2). The specific gravity of this clone was just above the trial average at 1.072. No hollow heart was noted in 130 cut tubers. Vine maturity for this variety appeared to be medium in 2012 but typically is observed to be much later (130 days). Lamoka continues to chip process well out of mid to late season storage and in some tests is chipping well at 47 ºF. The concern of tuber wet break down in storage continues to be raised with Lamoka. Blackleg, Pink Rot, Pythium Leak and Dry Rot are all suggested as causal agents. Lamoka appears to have storage rot susceptibility similar to Pike.

MSL292-A; this is a Michigan State University developed variety. In 2012, MSL292-A had an average yield at 400 cwt./A US#1 just below the trial average (Table 2). This variety had 91 percent marketable yield and a slightly below average specific gravity at 1.069. Raw internal tuber quality was good and tuber type was very uniform and round. Only one hollow heart in 120 cut tubers was reported. This variety is common scab susceptible. MSL292-A exhibited excellent chip quality out of the field and from storage in 2012 and early 2013. This variety has chipped well from storage at 50 °F.

B. USPB / SFA Chip Trial Results

The Michigan location of the USPB / SFA chip trial was on Sandyland Farms, LLC in Montcalm County in 2012. Table 3 shows the yield, size distribution and specific gravity of the entries when compared with Atlantic and Snowden. Table 4 shows the at-harvest raw tuber quality results. Table 5 shows the out-of-the-field chip quality evaluations from samples processed and scored by Herr Foods, Inc., Nottingham, PA and Table 6 provides the blackspot bruise susceptibility of each entry. Tables 7A and 7B provide a pre-harvest panel for each of the 16 varieties in the trial on two different dates. These tables compare tuber specific gravity, percent glucose and sucrose ratings taken on August 13th and August 27th, 2012 for each variety.

USPB / SFA Chip Trial Highlights

Atlantic and NY140 topped the yield table in 2012 followed by W4980-1, Snowden, NY148 (NYE106-4) and MSL292-A (Table 3). NY140 had the largest percentage of recorded oversize tubers in the trial (Table 3). W4980-1, W6483-5, W2978-3, AF4157-6, ND8304-2 and CO00188-4W had very low specific gravities. The varieties in the 2012 trial that displayed the greatest potential for commercialization were NY140, NY148 (NYE106-4) and MSL292-A. Yield potential and specific gravity were good for NY148 (NYE106-4) (Table 3). NY148 (NYE106-4), ND8305-1 and W5015-12 showed the greatest susceptibility to blackspot bruise (Table 6). AF4157-6, ND8304-2 and CO00188-4W were very mature on August 13th, which was approximately three weeks prior to vine kill (Table 7).

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 yield averages for the ten freshpack locations: Antrim, Delta, Ingham, Kalkaska, Monroe, Montcalm, Presque Isle, Sanilac, St. Joseph, and Washtenaw Counties.

Fresh Market Variety Highlights

One red skin, three yellow flesh and four russet lines are worthy of mention from the 2012 freshpack on-farm variety trials. They are W6002-1R (the round red), W6703-5Y, W6703-1Y and MSM288-2Y (the yellow flesh varieties), and the russets, AF3362-1Rus, Dakota Trailblazer, W7449-1Rus and A02062-1TERus,.

W6002-1R; this University of Wisconsin variety has a smooth bright dark red skin appearance with an oval tuber shape (Table 8). In the 2012 freshpack variety trials, this clone had a 352 cwt./A US#1 yield with a 1.063 specific gravity (Table 9). No hollow heart was observed in 30 cut tubers. Tuber size distribution was good with 86 percent of the tubers being marketable. Twelve percent oversize tubers were reported. The vine maturity of this clone is early.

W6703-5Y; this University of Wisconsin variety has a bright tuber appearance, yellow flesh and moderate common scab tolerance (Table 8). In the 2012 freshpack variety trials, this clone had a 353 cwt./A US#1 yield with a 1.073 specific gravity (Table 9). No hollow heart was noted in 40 cut tubers. Tuber size distribution was good with 85 percent of the tubers being marketable. The skin type of this variety is smooth and bright and the tubers are uniform in shape. The vine maturity is medium.

W6703-1Y; this University of Wisconsin variety has a uniform tuber type with a nice yellow flesh and common scab tolerance (Table 8). In 2012, W6703-1Y yielded 334 cwt./A US#1 exhibiting an early vine maturity (Table 9). The total yield of this variety was reported as 404 cwt./A. The percentage of the total tuber yield that was “B” sized was 17 percent and the specific gravity was 1.078.

MSM288-2Y; this Michigan State University variety has uniform tuber type with a nice yellow flesh. The tubers have pink eye color similar to Yukon Gold. In 2012, MSM288-2Y yielded 319 cwt./A US#1 with an early vine maturity (Table 9). The total yield of this variety was reported as 407 cwt./A. The percentage of the total tuber yield that was “B” sized was 18 and the specific gravity was 1.074. This variety expresses common scab susceptibility.

AF3362-1Rus; this University of Maine selection had a 448 cwt./A US#1 yield, an average specific gravity of 1.067 and three out of 130 tubers exhibited hollow heart (Table 9). This was the top yielding russet in 2012. Thirty percent of the marketable yield was oversized, warranting a closer in-row seed spacing than 12 inches. The tuber appearance was long and blocky with a nice russeted skin. Vine maturity was early. This variety appears very promising for the early russet market. AF3362-1Rus performed well across all geographic latitudes and it also has common scab tolerance.

Dakota Trailblazer; this is a variety developed at North Dakota State University. Averaged over eight locations, this variety yielded 388 cwt./A US#1 which placed it as the second highest yielding russet in 2012. The specific gravity was very high at 1.089. Twenty-eight tubers with hollow heart were reported in 110 cut tubers.

Vine maturity was medium-late. Tuber type was extremely blocky. Common scab susceptibility was observed.

W7449-1Rus; this University of Wisconsin selection had a 375 cwt./A US#1 yield, an average specific gravity of 1.073 and 2 of 40 tubers exhibited hollow heart (Table 9). The tuber's appearance was oblong to blocky with a nice russeted skin. Vine maturity was medium.

A02062-1TERus; this is a USDA Aberdeen, ID developed variety. Across seven locations in 2012, this variety on average yielded 335 cwt./A US#1 with a 1.065 specific gravity with no tubers exhibiting hollow heart out of 100 cut (Table 9). This variety has a very nice skin type and tuber shape. As a result of a smaller tuber set per plant, a 9.5 -10 inch in-row seed spacing is recommended. A02062-1TERus has a medium vine maturity similar to Russet Norkotah.

Table 1

2012 MSU Processing Potato Variety Trials

Entry	Pedigree	2012 Scab Rating*	Characteristics
Atlantic	Wauseon X B5141-6 (Lenape)	2.8	High yield, early maturing, high incidence of internal defects, check variety, high specific gravity
FL1879	Snowden X FL1207	2.3	High yield, late maturity, large tuber type, late season storage, medium specific gravity, check variety
Lamoka (NY139)	NY120 X NY115	1.5	High yield, mid-late season maturity, medium specific gravity, oval to oblong tuber type, low internal defects
Pike (NYE55-35)	Allegany X Atlantic	1.1	Average yield, early to mid-season maturity, small tuber size profile, early storage check variety, some internal defects, medium specific gravity
Snowden (W855)	B5141-6 X Wischip	2.6	High yield, late maturity, mid-season storage check variety, reconditions well in storage, medium to high specific gravity
A01143-3C	COA95070-8 X Chipeta	1.8**	Average yielding, scaly buff chipper; smaller tuber size, late maturity
AC00206-2W	AC87340-2 X Dakota Pearl	3.8	Below average yield, below average specific gravity, medium maturity, severe susceptibility to common scab
AC03452-2W	A94322-8C X COA96141-4	2.5	Below average yield, below average specific gravity, full season maturity, moderate susceptibility to common scab
AF4157-6	Yankee Chipper X Dakota Pearl	-	Medium early maturity, round to oblong netted tubers, good gravity, good chip color from the field and storage, common scab susceptible
BNC182-5	Tacna X B0766-3	-	Short dormancy, above average yield potential, moderate common scab resistance, average chip quality, late blight susceptible
CO00188-4W	A90490-1W X BC0894-2W	1.5**	Below average yield potential. small tuber size, minimal grade defects, medium-early maturity, high specific gravity, ability to recondition out of 40º F
CO00197-3W	A91790-13W X NDTX4930-5W	3.5**	Medium yield potential, small size profile, minimal grade defects, early maturity, medium-high specific gravity, ability to recondition out of 40º F

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.   ** = 2011 Data

Table 1 continuted

Entry	Pedigree	2012 Scab Rating*	Characteristics
CO02321-4W	NY115 X BC0894-2W	2.8	Average yield potential, average specific gravity, medium maturity, common scab susceptibility
MN99380-1Y	Atlantic X MSA091-1	-	Above average yield, medium maturity, moderate specific gravity, moderate scab resistance, oval oblong tuber shape, white skin and yellow flesh
MSL007-B	MSA105-1 X MSG227-2	1.5	Average yield, early to mid-season maturity, uniform tuber type, medium specific gravity, scab tolerant, heavy netted skin
MSL292-A	Snowden X MSH098-2	2.5	Above average yield, scab susceptible, late blight susceptible, medium specific gravity, long storage potential, uniform tuber type, heavy netted skin
MSN190-2	MSI234-6Y X MSG227-2	1.5	High specific gravity, earlier maturity, blackspot bruise resistant, average yield
MSQ086-3	Onaway X Missaukee (MSJ461-1)	1.9	Round tuber type, high yield potential, early bulking potential, low internal defect, moderate scab tolerance, medium-late vine maturity
MSQ089-1	A91790-13 X Missaukee (MSJ461-1)	1.9	Above average yield, uniform round tubers, medium maturity, good internal quality, average specific gravity
MSR061-1	Mega Chip (W1201) X NY121	1.9	Average yield, round tuber type with netted skin, low reducing sugars, PVY resistant, moderate late blight resistance
MSR127-2	MSJ167-1 X MSG227-2	1.5	Scab resistant, high specific gravity, good chip quality from storage, above average yield potential, medium-late maturity
MSR169-8Y	Pike X MSJ126-9Y	0.8	Below average yield, medium maturity, yellow flesh, average specific gravity, common scab resistant
MSS165-2Y	MSM188-1 X MSL159-AY	1.9	High yield, above average specific gravity, late maturity, uniform round tuber type, heavy netted skin, yellow flesh, good internal tuber quality
ND8304-2	ND860-2 x ND7083-1	-	Medium yield, medium early maturity, uniform round tuber type, smooth bright white skin color, white flesh, shallow eyes

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. ** = 2011 Data

Table 1 continuted

Entry	Pedigree	2012 Scab Rating*	Characteristics
ND8305-1	ND2471-8 X White Pearl	3.1	Medium maturity, medium vine vigor, medium yield potential, high specific gravity, uniform tubers with small size profile, chips well from cold storage
NY140	NY121 x NY115	2.8	Late season, dual purpose chip and table stock. High yields of large tubers, lightly textured skin.
NY148	NY128 x Marcy	1.8	Late season, high gravity, scab-resistant chip stock, good yield potential, medium to late season storage quality, black spot bruise susceptible
W4980-1	B0692-4 X W1355-1	1.9	Medium-early maturity for out-of-the-field chipping, moderate yield potential, low set
W5015-12	Brodick X W1355-1	2.6	High tuber set and yield, medium-late vine maturity, uniform size tubers, tubers tend toward flat shape, very flat in some environments
W6483-5	-	-	Above average yield, early maturity, common scab susceptible, below average specific gravity

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. ** = 2011 Data

Table 2

2012 Processing Potato Variety Trial
Overall Averages - Nine Locations
Allegan, Branch, Gratiot, Montcalm, & St. Joseph Counties

NUMBER OF		CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	VINE	VINE		CHIP
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	COMMENTS
3	BNC182-5	529	564	94	5	74	20	1	1.073	1.0	5	5	0	1	30	3.2	3.8	deep apical eye, tr common scab, sl pinkeye, misshapen tubers in pickouts	moderate SED
8	NY148	492	561	88	11	83	5	1	1.081	1.1	2	7	1	0	110	3.0	4.1	sl common scab, knobs, gc, misshapen tubers in pickouts	sl SED
5	NY140	489	541	90	7	80	10	3	1.068	1.3	0	29	2	1	80	3.2	4.3	sl to moderate common scab, tr alligator hide, misshapen tubers in pickouts	moderate SED
7	MSR127-2	449	495	91	8	84	7	1	1.074	1.1	3	17	0	0	100	3.0	3.8	sl common scab, uniform round tuber type, sl alligator hide, misshapen tubers and gc in pickouts	tr SED
8	MSL007-B	437	492	88	11	85	3	1	1.071	1.1	5	6	4	0	120	2.5	3.5	tr common scab, heavy netted skin, uniform round tuber type, misshapen tubers in pickouts	sl to moderate SED
6	**Snowden**	**430**	**497**	**86**	**14**	**81**	**5**	**0**	**1.072**	**1.0**	**0**	**39**	**7**	**0**	**90**	**3.6**	**3.6**	**moderate common scab, misshapen tubers in pickouts**	**sl SED**
5	AF4157-6	425	505	84	15	83	1	1	1.069	1.1	0	23	0	0	80	3.4	1.8	severe pitted scab, tr pinkeye, misshapen tubers in pickouts	sl SED in chips
6	MSS165-2Y	424	490	86	12	84	2	2	1.077	1.2	3	9	1	0	90	2.8	3.7	sl common scab, yellow flesh, sl pinkeye, uniform tuber type, misshapen tubers in pickouts	sl SED
9	Lamoka	422	453	93	5	84	9	2	1.072	1.1	0	40	2	0	130	3.5	2.8	sl common scab, some tubers with black leg, oval to oblong tuber shape, misshapen tubers and knobs in pickouts	sl SED
6	MSQ086-3	414	532	79	17	77	2	4	1.067	1.0	0	19	1	0	90	2.7	3.8	sl common scab, bright appearance, gc and knobs in pickouts	sl SED
7	W4980-1	412	474	86	13	84	2	1	1.069	1.0	1	15	36	0	100	3.9	2.3	moderate common scab, moderate heat necrosis, heavy netted skin, misshapen tubers and knobs in pickouts	moderate SED, noticable heat necrosis
5	CO02321-4W	404	487	82	17	81	1	1	1.073	1.1	0	17	2	0	80	3.8	2.5	severe pitted scab, round tuber type, misshapen tubers in pickouts	sl SED
3	MSQ089-1	404	445	91	9	89	2	0	1.065	1.0	0	13	0	1	30	3.0	3.5	moderate common scab, uniform round tuber type	tr SED
8	MSL292-A	400	436	91	9	86	5	0	1.069	1.1	1	22	20	0	120	2.9	2.3	moderate to severe common scab, flat apical to stem end, misshapen tubers in pickouts, heavy netted skin	sl SED
3	AC03452-2W	373	467	78	18	78	0	4	1.063	1.2	0	2	3	0	30	4.0	4.0	moderate pinkeye and alligator hide, misshapen tubers and gc in pickouts, some heat necrosis	tr SED
1	**Atlantic**	**372**	**419**	**89**	**11**	**80**	**9**	**0**	**1.081**	**1.0**	**0**	**0**	**2**	**1**	**10**	**3.5**	**1.5**	**misshapen tubers in pickouts**	**VD in chips, sl SED**
7	MSN190-2	369	445	83	16	78	5	1	1.079	1.1	0	22	3	0	100	2.8	2.1	sl common scab, sl pinkeye and alligator hide, heavy netted skin, misshapen tubers in pickouts	sl SED
6	MSR169-8Y	357	417	84	14	82	2	2	1.068	1.2	2	11	0	0	90	2.6	2.5	netted skin, light yellow flesh, tr pinkeye, misshapen tubers and gc in pickouts	sl SED
5	**Pike**	**339**	**378**	**89**	**10**	**87**	**2**	**1**	**1.068**	**1.2**	**0**	**11**	**3**	**0**	**80**	**3.2**	**2.7**	**sl common scab, tr alligator hide, misshapen tubers, knobs, and gc in pickouts**	**sl SED**
3	AC00206-2W	302	395	77	22	77	0	1	1.066	1.0	2	1	1	0	30	3.3	3.0	moderate to severe common scab, small tuber size, misshapen tubers in pickouts	tr SED
	MEAN	**412**	**475**						**1.071**										

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
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]VINE MATURITY RATING
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine, some flowering)

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	**504**	**551**	**92**	**6**	**85**	**7**	**2**	**1.077**
NY140	498	540	93	6	80	13	1	1.072
W4980-1	484	521	75	25	64	11	0	1.064
Snowden	**446**	**495**	**90**	**10**	**81**	**9**	**0**	**1.070**
NY148	438	513	86	14	85	1	0	1.083
MSL292-A	392	430	91	9	88	3	0	1.068
W6483-5	377	460	75	13	68	7	12	1.059
MSR061-1	374	438	86	13	75	11	1	1.071
W2978-3	368	500	73	25	73	0	2	1.059
AF4157-6	367	453	81	18	80	1	1	1.064
CO02321-4W	365	437	83	16	81	2	1	1.073
CO00197-3W	315	451	70	29	70	0	1	1.067
A01143-3C	288	386	75	12	75	0	13	1.075
W5015-12	272	408	59	41	59	0	0	1.076
ND8304-2	252	339	74	23	74	0	3	1.058
MN99380-1Y	243	401	61	34	61	0	5	1.065
CO00188-4W	242	376	64	36	64	0	0	1.062
ND8305-1	164	279	59	41	59	0	0	1.075
MEAN	**355**	**443**	**77**	**21**	**73**	**4**	**2.3**	**1.069**

*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	**8**	**1**	**2**	**0**	**30**
NY140	1	9	0	0	30
W4980-1	0	3	10	0	30
Snowden	**6**	**8**	**0**	**0**	**30**
NY148	0	0	0	1	30
MSL292-A	0	3	1	0	30
W6483-5	0	8	5	0	30
MSR061-1	1	4	0	0	30
W2978-3	0	1	1	0	30
AF4157-6	1	8	0	0	30
CO02321-4W	1	0	0	0	30
CO00197-3W	0	9	0	0	30
A01143-3C	0	2	0	0	30
W5015-12	0	4	0	0	30
ND8304-2	0	1	0	0	30
MN99380-1Y	0	8	0	1	30
CO00188-4W	0	0	0	0	30
ND8305-1	0	0	0	0	30

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

Table 5. 2012 Post-Harvest Chip Quality[1]						
	Agtron	SFA[2]	Specific	Percent Chip Defects[3]		
Entry	Color	Color	Gravity	Internal	External	Total
Atlantic	**60.1**	**3**	**1.062**	**15.1**	**19.6**	**34.7**
NY140	61.5	4	1.060	32.5	27.6	60.1
W4980-1	57.4	4	1.055	24.3	27.0	51.3
Snowden	**60.6**	**3**	**1.068**	**20.3**	**6.2**	**26.5**
NY148	55.3	2	1.077	20.9	25.9	46.8
MSL292-A	60.9	3	1.061	12.0	31.6	43.6
W6483-5	57.3	4	1.060	34.7	33.0	67.7
MSR061-1	60.5	4	1.067	35.2	7.6	42.8
W2978-3	55.5	3	1.060	32.2	17.9	50.1
AF4157-6	53.7	4	1.055	12.2	51.2	63.4
CO02321-4W	55.9	4	1.060	19.6	50.9	70.5
CO00197-3W	59.6	4	1.055	18.3	57.2	75.5
A01143-3C	59.4	3	1.072	13.0	5.0	18.0
W5015-12	60.7	3	1.060	13.6	28.6	42.2
ND8304-2	57.8	4	1.055	14.4	54.9	69.3
MN99380-1Y	63.9	4	1.055	25.9	0.1	26.0
CO00188-4W	59.0	2	1.060	10.0	12.2	22.2
ND8305-1	59.9	4	1.060	7.2	26.1	33.3

[1] Samples collected October 2nd and processed by Herr Foods, Inc., Nottingham, PA on October 4, 2012.

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]								
								Percent	Average								Percent	Average
	# of Bruises Per Tuber						Total	Bruise	Bruises Per	# of Bruises Per Tuber						Total	Bruise	Bruises Per
Entry	0	1	2	3	4	5	Tubers	Free	Tuber	0	1	2	3	4	5	Tubers	Free	Tuber
Atlantic	**11**	**12**	**2**				**25**	**44**	**0.6**	**2**	**8**	**8**	**5**	**1**	**1**	**25**	**8**	1.9
NY140	16	8	1				25	64	0.4	5	6	7	5		2	25	20	1.8
W4980-1	20	5					25	80	0.2	8	15	1	1			25	32	0.8
Snowden	**17**	**7**	**1**				**25**	**68**	0.4	**12**	**10**	**1**	**2**			**25**	**48**	**0.7**
NY148	8	7	5	5			25	32	1.3	1	2	4	1	6	11	25	4	3.7
MSL292-A	19	6					25	76	0.2	14	10	1				25	56	0.5
W6483-5	23	2					25	92	0.1	19	5	1				25	76	0.3
MSR061-1	23	2					25	92	0.1	12	11	1	1			25	48	0.6
W2978-3	23	2					25	92	0.1	16	8	1				25	64	0.4
AF4157-6	23	2					25	92	0.1	20	5					25	80	0.2
CO02321-4W	18	6	1				25	72	0.3	16	5	4				25	64	0.5
CO00197-3W	19	5	1				25	76	0.3	15	10					25	60	0.4
A01143-3C	20	3	2				25	80	0.3	17	5	3				25	68	0.4
W5015-12	19	3	1	1	1		25	76	0.5	1	8	3	10	2	1	25	4	2.3
ND8304-2	20	5					25	80	0.2	16	4	5				25	64	0.6
MN99380-1Y	20	5					25	80	0.2	13	10		1	1		25	52	0.7
CO00188-4W	22	3					25	88	0.1	21	2	2				25	84	0.2
ND8305-1	12	12	1				25	48	0.6		2	6	7	7	3	25	0	3.1

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

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

Table 7A. Pre-Harvest Panels, 8/13/12								
				Canopy		Number of		Average[5]
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Rating[3]	Uniform.[4]	Hills	Stems	Tuber Weight
Atlantic	**1.080**	**0.002**	**0.643**	**75**	**90**	**4**	**12**	**4.37**
NY140	1.064	0.002	0.486	90	90	3	8	4.68
W4980-1	1.067	0.004	0.540	40	80	4	12	4.39
Snowden	**1.069**	**0.002**	**0.527**	**75**	**50**	**4**	**15**	**4.65**
NY148	1.075	0.002	0.419	95	95	4	13	4.21
MSL292-A	1.072	0.002	0.660	50	50	4	13	4.19
W6483-5	1.063	0.008	0.632	30	80	4	18	5.00
MSR061-1	1.070	0.002	0.482	75	80	5	13	4.26
W2978-3	1.060	0.003	0.686	40	50	4	11	3.33
AF4157-6	1.067	0.011	0.546	20	60	4	12	3.33
CO02321-4W	1.079	0.004	0.443	60	75	3	14	4.04
CO00197-3W	1.072	0.003	0.748	50	90	3	14	2.48
A01143-3C	1.069	0.005	1.232	85	90	7	29	2.58
W5015-12	1.074	0.002	0.409	75	90	2	12	2.04
ND8304-2	1.064	0.002	0.703	20	80	4	18	3.23
MN99380-1Y	1.064	0.002	0.677	65	75	4	10	2.57
CO00188-4W	1.066	0.002	0.366	25	80	3	18	2.12
ND8305-1	1.079	0.003	0.488	60	70	4	15	1.83

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

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

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

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

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

Table 7B. Pre-Harvest Panels, 8/27/12								
				Canopy		Number of		Average[5]
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Rating[3]	Uniform.[4]	Hills	Stems	Tuber Weight
Atlantic	**1.078**	**0.003**	**0.722**	**5**	**85**	**4**	**13**	**6.88**
NY140	1.075	0.001	0.512	30	95	3	10	4.59
W4980-1	1.065	0.002	0.729	10	90	4	22	4.46
Snowden	**1.067**	**0.002**	**0.727**	**50**	**95**	**4**	**17**	**4.68**
NY148	1.080	0.001	0.32	50	100	4	18	3.46
MSL292-A	1.069	0.002	0.892	15	90	3	12	4.32
W6483-5	1.061	0.001	0.546	0	100	5	20	5.37
MSR061-1	1.070	0.002	0.804	25	90	4	13	4.39
W2978-3	1.059	0.002	0.802	0	100	4	14	3.45
AF4157-6	1.063	0.002	0.823	0	100	4	17	3.29
CO02321-4W	1.078	0.002	0.791	0	100	4	14	3.79
CO00197-3W	1.071	0.002	0.922	0	100	3	13	2.94
A01143-3C	1.076	0.003	1.195	50	100	3	19	3.69
W5015-12	1.075	0.002	0.922	10	90	3	15	2.71
ND8304-2	1.060	0.002	1.058	0	100	4	19	3.59
MN99380-1Y	1.062	0.002	0.916	0	100	3	12	2.60
CO00188-4W	1.064	0.001	0.505	0	100	4	19	3.02
ND8305-1	1.076	0.001	0.630	15	90	3	19	1.97

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

2012 MSU Tablestock Potato Variety Trials

Entry	Pedigree	2012 Scab Rating*	Characteristics
Goldrush Russet (ND1538-1Rus)	ND450-3Rus X Lemhi Russet	0.8	Medium maturity, oblong-blocky to long tubers, bright white flesh, common scab resistance, average yield potential
Norwis (FL657)	RD289-18 X Manona	2.3	Mid-season maturity, blocky to oval tubers, pale yellow flesh, common scab susceptible
Onaway	USDA X96-56 X Katahdin	2.0	High yield, early maturity, round tuber type, low specific gravity, smooth skin, white flesh, medium deep eyes, few internal defects, check variety
Reba (NY 87)	Monona X Allegany	2.2	High yield, bright tubers, low incidence of internal defects, mid to late season maturity, medium – low specific gravity
Red Norland	ND 626 X Red Kote	1.4	Early maturity, medium yield, low specific gravity, smooth round to oblong tubers, medium red skin color
Russet Norkotah (ND534-4Rus)	ND9526-4Rus X ND9687-5Rus	1.9	Average yield, mid-season maturity, long to oval tubers, heavy russet skin, check variety, low specific gravity
Silverton Russet (AC83064-6)	A76147-2 X A 7875-5	0.8	High yield, oblong to long blocky tuber type, medium russet skin, masks PVY, medium specific gravity, possible Sencor & Linuron susceptibility
A01124-3Rus	Bannock Russet X A94020-3	1.5	Medium yield, mid-season maturity, medium specific gravity, heavy russeting, nice uniform blocky tuber appearance
A02062-1TERus	A97201-4 X A97299-1	1.0	Long tuber type, medium-heavy russeting, higher U.S. No. 1 yields and larger tuber size than Russet Norkotah, early to mid-season maturity
AF3362-1Rus	Reeves Kingpin X Silverton Russet	1.3	A long russet with good yield, processing potential and generally good appearance, common scab tolerance, early bulking potential, medium russet skin

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. **2011 Data

Table 8 Continued

Entry	Pedigree	2012 Scab Rating*	Characteristics
CF7523-1	-	3.1	Midseason tablestock, possible substitute for Superior, tubers round to oblong, bright white skin, good yielder, resistant to golden nematode, net necrosis, early blight, and verticillium wilt.
CO03187-1Rus	Rio Grande Russet X A9304-3	0.6	Long tuber type, processing potential, resistant to blackspot and enzymatic browning, early maturing, medium specific gravity
CO03276-4Rus	CO35086-8Rus X Blazer Russet	0.1	Oblong tuber type, processing potential, resistant to blackspot and enzymatic browning, average specific gravity, medium maturing
CO03276-5Rus	CO35086-8Rus X Blazer Russet	0.3	Long tuber type, processing potential, resistant to blackspot and enzymatic browning, medium specific gravity, medium maturing
CO04159-1R	-	2.1	Below average yield potential, medium specific gravity, early maturity
CO04211-4Rus	-	1.4	Average yield potential, below average specific gravity, medium maturity, common scab tolerant
CO04220-7Rus	-	0.9	Average yield potential, below average specific gravity, early maturity, common scab resistant
CO04233-1Rus	-	0.8	Below average yield, below average specific gravity, early to medium maturity
Dakota Trailblazer (AOND95249-1Rus)	A98163-3LS x A8914-4	2.4	High yield, uniform blocky tubers, dark heavy netted skin, medium-late maturity, high gravity, common scab susceptible
Michigan Purple Sport I	-	2.1	Sport of Michigan Purple with white and purple skin
Michigan Purple Red Sport II	-	2.1	Sport of Michigan Purple with red and purple skin
MSM288-2Y	MSG145-1 X MSA097-1Y	2.8	A bright yellow flesh selection similar in type to Yukon Gold, common scab susceptible, uniform tuber type, pink eyes

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. **2011 Data

Table 8 Continued

Entry	Pedigree	2012 Scab Rating*	Characteristics
MSQ341-BY	MSJ126-9Y X NY120	1.4	Above average yield potential, nice round shape, good yellow flesh color, smooth skin type, common scab tolerant, pinkeye susceptible
MSQ440-2	MSK214-1R X Missaukee (MSJ461-1)	1.5	Uniform round tubers, very bright white skin, common scab tolerance
Spartan Splash (MSQ425-4YSPL)	MI Purple X MSK247-9Y	1.8	Uniform round tubers, yellow flesh, purple splashes on skin
MSR186-3P	MN19525R X MSK034-1	-	High yielding, purple skin and white flesh, late blight resistant
MSR214-2P	MI Purple X MSK247-9Y	1.9	Common scab tolerant purple skin with white flesh
MSR217-1R	NDTX4271-5R X Missaukee (MSJ461-1)	2.8	Attractive dark red skin, round tuber type, below average yield
MSS544-1R	CO93037-6R X MNR-8RR	1.4	Attractive dark red skin, round tuber type, common scab resistance, below average yield
NY150	NY 121 X Jacqueline Lee (MSG274-3)	2.3	Early season tablestock variety, large tuber set, small tuber size, bright appearance, smooth skin, shallow eyes, bright white flesh, intermediate common scab resistance
Purple Heart	-	2.6	High yield of round tubers with red skin and purple flesh
Russet Norkotah LT	Russet Norkotah Line Selection	2.2	Above average yield, mid-season maturity, long to oval tubers, heavy russet skin, low specific gravity, better vigor than standard Russet Norkotah
Teton Russet (A0008-1TE)	Blazer Russet X Classic Russet	0.4	Medium yield, nice blocky tuber type, white flesh, medium russet skin, early maturity, low specific gravity, fusarium dry rot tolerance, susceptible to growth cracking
W6002-1R	B1491-5 X W1100R	2.3	Good skin color, very uniform tubers with good market appeal, good skin set, medium-high yield

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. **2011 Data

Table 8 Continued

Entry	Pedigree	2012 Scab Rating*	Characteristics
W6234-4Rus	Umatilla Russet X A9014-2	2.5	Large size, moderate specific gravity, nice fry color, light russeting on skin
W6511-1R	Kankan X W2275-9R	1.8	Dark red skin color holds in storage, oblong tuber shape, high tuber set
W6703-1Y	Satina X W2275-2Y	1.1	Slightly better shape than W6703-5Y, common scab tolerant, medium yellow flesh
W6703-5Y	Satina X W2275-2Y	1.1	Common scab tolerant, dark yellow flesh
W7449-1Rus	AWN86514-2Rus X Silverton Russet	1.8	Excellent blocky tuber type, nice russeting on skin, some internal necrosis

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.   **2011 Data

Table 9

2012 Freshpack Potato Variety Trial
Overall Averages - Twelve Locations
Antrim, Delta, Ingham, Kalkaska, Monroe, Montcalm, Presque Isle, Sanilac, St. Joseph, & Washtenaw Counties

NUMBER OF		CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	VINE	VINE	
LOCATIONS	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	VIGOR[3]	MATURITY[4]	COMMENTS
10	AF3362-1Rus	448	539	82	9	52	30	9	1.067	3	16	36	13	130	3.4	1.9	sl alligator hide, great size and shape, misshapen tubers in pickouts
8	Dakota Trailblazer	388	474	81	10	59	22	9	1.089	28	16	0	0	110	3.0	3.8	sl alligator hide, moderate pinkeye, moderate common scab, blocky tuber type, misshapen tubers in pickouts
6	**Silverton Russet**	**388**	**482**	**80**	**12**	**56**	**24**	**8**	**1.068**	**5**	**8**	**3**	**1**	**90**	**3.7**	**3.4**	**moderate alligator hide, misshapen tubers in pickouts, uniform tuber type**
2	**GoldRush**	**387**	**524**	**74**	**13**	**57**	**17**	**13**	**1.067**	**3**	**3**	**0**	**0**	**20**	**2.5**	**2.8**	**uniform tuber type, some tubers with rot**
2	W7449-1Rus	375	477	78	21	72	6	1	1.073	2	0	17	3	40	3.2	3.4	sl common scab, moderate alligator hide and pinkeye, very few pickouts
1	Alpine Russet	369	542	68	26	68	0	6	1.088	0	2	0	0	10	2.5	2.0	misshapen tubers in pickouts, no scab or pinkeye
4	W6703-5Y	353	417	85	6	75	10	9	1.073	0	5	4	0	40	4.0	3.1	moderate alligator hide, misshapen tubers and gc in pickouts, netted skin, nice tuber type
3	W6002-1R	352	405	86	13	74	12	1	1.063	0	2	0	0	30	4.2	1.5	moderate scab, oval tuber type, nice red skin color, misshapen tubers in pickouts
5	W6234-4Rus	346	431	78	12	60	18	10	1.074	7	11	2	2	80	3.6	2.3	moderate scab, sl alligator hide, misshapen tubers in pickouts, light russeting
7	A02062-1TERus	335	470	71	9	49	22	20	1.065	0	17	1	0	100	2.6	2.4	misshapen tubers, knobs, and gc in pickouts, sl alligator hide, some glassy end, some rotten tubers
4	W6703-1Y	334	404	82	17	80	2	1	1.078	0	0	1	0	40	3.9	2.1	sl scab, uniform round tuber type, creamy yellow flesh
4	**Red Norland**	**322**	**388**	**81**	**16**	**77**	**4**	**3**	**1.061**	**2**	**6**	**1**	**0**	**40**	**4.3**	**1.4**	**tr common scab, round tuber type**
5	**Reba**	**321**	**355**	**88**	**10**	**60**	**28**	**2**	**1.074**	**9**	**8**	**0**	**0**	**50**	**4.0**	**2.7**	**sl common scab, misshapen tubers in pickouts**
7	MSM288-2Y	319	407	79	18	74	5	3	1.074	1	4	2	0	70	4.0	1.9	moderate common scab, yellow flesh, pink eyes, moderate alligator hide, few pickouts
7	MSQ341-BY	312	352	87	12	72	15	1	1.076	1	37	8	11	70	3.1	2.4	severe pinkeye, misshapen tubers in pickouts
3	MSR214-2P	308	374	82	8	69	13	10	1.064	0	0	0	0	30	2.7	3.3	moderate to severe common scab, misshapen tubers and gc in pickouts
5	A01124-3Rus	308	403	78	7	62	16	15	1.071	25	3	1	0	80	2.5	2.7	uniform long tubular type, misshapen tubers and gc in pickouts
4	MSR186-3P	307	376	82	12	72	10	6	1.072	0	11	0	0	40	3.1	3.1	sl common scab, misshapen tubers in pickouts
6	CO03276-4Rus	301	506	58	21	50	8	21	1.070	8	6	0	2	90	3.5	2.4	misshapen tubers, gc, knobs, and bottle necking in tubers, small tuber type
1	Mesa Russet	292	453	64	33	63	1	3	1.077	4	0	0	0	10	2.5	3.0	misshapen tubers in pickouts, heavy russeted skin, uniform type

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
7	Russet Norkotah LT	292	395	70	17	52	18	13	1.068	31	17	1	0	100	3.4	3.3	moderate pinkeye and alligator hide, misshapen tubers, knobs, and gc in pickouts, some glassy end
6	**Russet Norkotah**	**289**	**394**	**72**	**15**	**52**	**20**	**13**	**1.063**	**19**	**12**	**2**	**1**	**90**	**2.9**	**2.5**	**moderate alligator hide and pinkeye, misshapen tubers and gc in pickouts, sl common scab**
8	Teton	279	403	66	16	54	12	18	1.064	29	8	0	0	100	2.8	2.2	moderate alligator hide and pinkeye, misshapen tubers and severe gc in pickouts
2	CO04220-7Rus	279	397	69	11	68	1	20	1.058	1	9	4	1	40	2.6	1.6	misshapen tubers and knobs in pickouts, sl alligator hide
2	CO04211-4Rus	270	444	59	23	59	0	18	1.060	1	5	19	0	40	2.9	2.1	moderate common scab, small tubers, misshapen tubers and knobs in pickouts
6	CO03276-5Rus	267	456	58	21	48	10	21	1.066	9	10	0	2	90	3.6	2.4	misshapen tubers and bottle necking in pickouts
8	MSQ440-2	265	311	83	16	76	7	1	1.062	0	43	0	0	70	2.6	2.3	sl common scab, bright white skin type, misshapen tubers in pickouts
2	W6511-1R	251	392	65	34	57	8	1	1.077	0	2	0	0	20	3.5	2.3	moderate common scab, moderate alligator hide
2	CO04233-1Rus	245	380	66	21	56	10	13	1.061	7	1	1	1	40	1.8	2.1	moderate alligator hide and pinkeye, misshapen tubers and gc in pickouts
2	CF7523-1	174	342	50	26	48	2	24	1.067	0	4	0	0	20	3.5	3.0	misshapen tubers and knobs in pickouts, deep apical eye
6	CO03187-1Rus	174	348	48	41	47	1	11	1.069	1	8	3	1	90	3.6	2.0	misshapen tubers, knobs, and bottle necking in pickouts, small blocky type
2	**Onaway**	**170**	**266**	**65**	**27**	**63**	**2**	**8**	**1.064**	**0**	**7**	**1**	**0**	**20**	**4.0**	**1.8**	**misshapen tubers and gc in pickouts, sl alligator hide, deep apical eye**
2	CO04159-1R	169	209	80	19	78	2	1	1.072	0	0	0	0	20	3.8	1.8	moderate common scab
1	**Norwis**	**168**	**220**	**77**	**13**	**68**	**9**	**10**	**1.053**	**0**	**0**	**0**	**0**	**10**	**3.0**	**3.0**	**misshapen tubers in pickouts**
5	MSR217-1R	157	199	77	21	73	4	2	1.065	0	5	1	0	50	2.5	2.3	moderate scab, some gc in pickouts
4	MSS544-1R	130	245	51	34	50	1	15	1.062	0	9	7	0	40	3.3	1.9	moderate to severe alligator hide, some anthocyanin leakage into tuber flesh, misshapen tubers and gc in pickouts
6	NY150	95	284	23	64	23	0	13	1.073	0	12	1	0	50	3.6	1.8	moderate common scab, very small tuber size, bright white skin
1	**Chieftan**	**87**	**139**	**62**	**32**	**59**	**3**	**6**	**1.062**	**0**	**2**	**2**	**0**	**10**	**1.5**	**1.5**	**heat sprouts in pickouts, pink instead of red skin**
1	Snowbird	76	118	64	23	64	0	13	1.062	1	3	0	0	10	5.0	N/A	round to oblong tuber type, moderate common scab, bright skin appearance
	MEAN	**274**	**377**						**1.068**								

tr = trace, sl = slight, N/A = not applicable
SED = stem end defect, gc = growth crack

[1]SIZE

Bs: < 1 7/8" or <4oz.

As: 1 7/8" - 3.25" or 4-10oz.

OV: > 3.25" or >10oz.

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

Ratings: 1 - 5

1: Slow Emergence

5: Early Emergence (vigorous vine, some flowering)

[4]VINE MATURITY RATING

Ratings: 1 - 5

1: Early (vines completely dead)

5: Late (vigorous vine, some flowering)

2012 COLORADO POTATO BEETLE RESEARCH UPDATE

Zsofia Szendrei (szendrei@msu.edu) and Adam Byrne
Department of Entomology, Michigan State University, East Lansing, MI 48824
Lab website: http://vegetable.ent.msu.edu/

Field evaluations of registered and experimental insecticides for managing Colorado potato beetle on potatoes

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

METHODS

Twelve insecticide treatments and an untreated check (Table 1) were tested at the MSU Montcalm Research Farm, Entrican, MI for control of Colorado potato beetle. 'Atlantic' potato seed pieces were planted 12 in. apart, with 34 in. row spacing on 9 May 2012. Treatments were replicated four times in a randomized complete block design. Plots were 50 ft. long and three rows wide with untreated guard rows bordering each plot.

A16901, Admire Pro, and Platinum 75 SG treatments were applied as in-furrow sprays at planting. Foliar treatments were first applied at greater than 60% Colorado potato beetle egg hatch on 11 June. Based on the economic threshold of more than one large larva per plant, additional first generation sprays were needed for Admire Pro (19 & 26 June, 3 July), Athena (26 June), Blackhawk (26 June), F9318 (26 June & 3 July), the low rate of Torac 15 EC (26 June & 3 July), and the high rate of Torac 15 EC (26 June); no subsequent applications were necessary for any of the Benevia 10 OD treatments. All applications were made using a single-nozzle hand-held boom (30 gallons/acre and 30 psi).

Post-spray counts of first generation Colorado potato beetle adults, small larvae (1st and 2nd instars), and large larvae (3rd and 4th instars) from five randomly selected plants from the middle row of each plot were made weekly, starting on 18 June. Plots were visually rated for defoliation weekly by estimating total defoliation per plot.

The numbers of small larvae, large larvae, and adults, as well as the defoliation ratings, were transformed log (x + 1) prior to analysis. Analysis of variance was used for data analysis and ad-hoc Tukey means separation was used to compare treatment means ($P < 0.05$).

RESULTS

Except for Admire Pro and Athena, all treatments resulted in significantly fewer small larvae than the untreated control, while all treatments significantly reduced the number of large larvae per plant, compared to the untreated (Table 1).

There were also significant differences in numbers of large larvae among the insecticide treatments. All three systemic products (Admire Pro, A16901, and Platinum 75 SG) performed well, with A16901 having significantly fewer large larvae than six of the foliar products. Among the foliar products, Admire Pro required weekly sprays, while F9318 and the low rate of Torac 15 EC were applied three of the four weeks. Athena, Blackhawk, and the high rate of Torac 15 EC required one subsequent application, all two weeks after the initial application. Of these, however, only Blackhawk provided reduction in average large larvae below the threshold of one per plant. Despite one fewer application for the high rate of Torac 15 EC, no significant differences in beetle life stages or defoliation were noted between the high and low rates for this product. All three Benevia 10 OD treatments required only the initial foliar application to provide first generation beetle control.

The untreated plots had significantly greater defoliation compared to all other treatments. The seasonal defoliation average was 36.6% in the untreated plots, compared to less than 6% for all other treatments. Differences in defoliation among insecticide treated plots ranged from 1.1 to 5.9%. Neonicotinoid insecticides are still providing sufficient Colorado potato beetle control for Michigan farmers, but new chemistries like Benevia 10 OD are also proving to be effective.

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

Treatment	Insecticide class	Application mode	Rate	Adult	Small Larva	Large Larva	% defoliation
Untreated				1.2 b	6.3 f	5.0 f	36.6 e
Benevia 10 OD	Ryanodine receptor modulator	foliar	5 fl oz/A	0.3 a	0.5 abc	0.7 abcd	3.8 abcd
Benevia 10 OD + MSO	Ryanodine receptor modulator	foliar	5 fl oz/A + 0.5% v/v	0.6 ab	0.7 abc	0.9 abcd	5.6 cd
Benevia 10 OD	Ryanodine receptor modulator	foliar	6.75 fl oz/A	0.5 ab	0.8 abc	0.9 bcd	5.9 bcd
Admire Pro	Nicotinic acetylcholine receptor agonist	foliar	1.3 fl oz/A	0.5 ab	3.8 ef	1.6 de	3.1 bcd
Blackhawk	Nicotinic acetylcholine allosteric activator	foliar	2.5 oz/A	0.5 ab	0.7 abc	0.8 abcd	3.0 bcd
Athena	Sodium channel modulator & chloride channel activator	foliar	17 fl oz/A	0.5 ab	3.2 def	2.1 e	3.7 cd
F9318		foliar	19 fl oz/A	0.3 a	2.0 cde	2.1 e	4.2 d
Torac 15 EC + Dyne-Amic	Mitochondrial complex I electron transport inhibitor	foliar	14 fl oz/A + 0.5% v/v	0.4 a	1.7 bcd	1.6 cde	4.4 d
Torac 15 EC + Dyne-Amic	Mitochondrial complex I electron transport inhibitor	foliar	17 fl oz/A + 0.5% v/v	0.3 a	1.8 cd	1.0 cde	2.6 abcd
Admire Pro	Nicotinic acetylcholine receptor agonist	infurrow	8.7 fl oz/A	0.5 ab	0.4 abc	0.5 abc	1.9 abc
Platinum 75 SG	Nicotinic acetylcholine receptor agonist	infurrow	2.66 oz/A	0.6 ab	0.2 ab	0.0 ab	1.1 ab
A16901		infurrow	10 oz/A	0.5 ab	0.0 a	0.0 a	1.1 a

Different letters within a column denote statistically significant differences among treatments ($P < 0.05$, Tukey's HSD). Data transformed for analysis with log (x+1), non-transformed means presented in table.

Susceptibility of Colorado potato beetle populations to imidacloprid and thiamethoxam

Imidacloprid (i.e.: Admire Pro) and thiamethoxam (i.e.: Platinum, Actara) continue to be the most common means of Colorado potato beetle management. Today, greater than 75% of the commercial potato 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 resistance management strategies.

Our objective was to continue gathering data on susceptibility to imidacloprid and thiamethoxam in Colorado potato beetle populations collected from commercial potato fields in Michigan and other regions of the United States. To accomplish this objective, 13 Colorado potato beetle populations (eight Michigan populations and five populations collected in other states) were bioassayed with imidacloprid and/or thiamethoxam.

METHODS

During 2012, eight Colorado potato beetle populations were collected from four Michigan counties (Ingham, Montcalm, Tuscola, and Washtenaw). Cooperators also provided populations from Idaho, New York, Maine, and Virginia. One susceptible laboratory strain was also tested (Table 1). To assure only healthy beetles were tested, newly received beetles were maintained at room temperature and 16:8 L:D photoperiod and fed pesticide-free, greenhouse-grown potato foliage for 3-7 days.

Adult Colorado potato beetles were treated with 1 µl of acetone/insecticide solution of known concentration applied to the ventral surface of the abdomen using a 50 µl Hamilton® microsyringe. Two populations with known resistance issues (Jamesport, NY and Tuscola, MI) required two applications of 1 µl of acetone/insecticide solution per beetle to achieve the desired dose (ie., 1 µl of 20.0 µg/µl plus 1 µl of 10.0 µg/µl to get a dose of 30.0 µg/µl). A range of four to 11 concentrations, plus an acetone-only control, was selected for each population, depending on the number of available beetles and known resistance history for each population. In each bioassay, 27-40 adults were treated with each concentration (nine to 10 beetles per dish and three to four dishes per concentration). Following treatment, beetles were placed in 100 mm diam. Petri dishes lined with Whatman® No. 1 filter paper and provided with fresh potato foliage. They were kept at 25±1°C and the foliage and filter paper were checked daily and changed as needed.

Beetle response was assessed 7 days post treatment [Painter, VA was assessed after 6 days]. A beetle was classified as dead if its abdomen was shrunken, it did not move when its legs or tarsi were pinched, and its elytra were darkened. A beetle was classified as walking and healthy if it was able to grasp a pencil and walk forward normally. A beetle was classified as poisoned if its legs were extended and shaking, it was unable to right itself or grasp a pencil, and it was unable to walk forward normally at least one body length. Beetles that had died due to Beauvaria spp. infection were excluded from analysis; these beetles were easily recognized by their pale, petrified appearance and/or presence of white filamentous fungi. Dead and poisoned beetle numbers were pooled for analysis. Data were analyzed using standard log-probit analysis (SAS Institute, 2009).

RESULTS

The imidacloprid LD_{50} value (dose lethal to 50% of the beetles) for the susceptible laboratory strain was 0.075 µg/beetle (Table 2). The LD_{50} values from the field for imidacloprid ranged from 0.195 µg/beetle (MSU) to 3.164 µg/beetle (Sackett Potatoes Field 153) for Michigan populations. The imidacloprid LD_{50} values from the out-of-state populations ranged from 0.210 µg/beetle (Painter, VA) to 11.570 (Jamesport, NY).

LD_{50} values for all populations were significantly higher than the susceptible laboratory strain. In 2012, 75% of the Michigan samples were greater than 10-fold resistant to imidacloprid, compared to 57% in 2011, 60% in 2010, and 85% in 2009.

The thiamethoxam LD_{50} value for the susceptible laboratory strain was 0.090 µg/beetle (Table 1). LD_{50} values for thiamethoxam in Michigan ranged from 0.140 µg/beetle (MSU) to 0.464 µg/beetle (Sackett Potatoes Field 153), and from 0.109 µg/beetle (Painter, VA) to 0.861 µg/beetle (Jamesport, NY) for out-of-state populations. No Michigan populations were greater than 10-fold resistant to thiamethoxam.

In general, resistance values across the country are very similar to those in recent years. As long as growers continue to use a variety of insecticide modes of action when managing Colorado potato beetles, it appears that the neonicotinoids can continue to play a major role. Most importantly, it is essential that growers refrain from using foliar products containing neonicotinoids, when a neonicotinoid was applied at planting.

Table 1. Colorado potato beetle populations tested for susceptibility to imidacloprid and thiamethoxam in 2012.

Michigan populations

Anderson Brothers Field 26 Summer adults were collected on 24 July 2012 by Mark Otto, Agri-Business Consultants, Inc., from commercial potato fields in Montcalm County.

DuRussell Summer adults were collected on 3 July 2012 from a commercial potato field near Manchester, Washtenaw County.

Greenville Summer adults were collected on 20 July 2012 by Mark Otto, Argi-Business Consultants, Inc. from a commercial potato field (ABC-TB 7 & 22) near Greenville, Montcalm County.

MSU Overwintered adults were collected on 8 June 2012 from potato research plots on the campus of Michigan State University, Ingham County.

Sackett Potatoes Adults were collected by Mark Otto and/or Loren Wernette, Agri-Business Consultants, Inc. from commercial potato fields in Montcalm County.

Field 9 Summer adults were collected on 9 July 2012.

Field 26 Overwintered adults were collected in early June 2012.

Fields 153 Summer adults were collected on 9 July 2012.

Tuscola Summer adults were collected on 3 July 2012 by Brice Stine, Walther Farms, from a commercial potato field near Caro, Tuscola County.

Out-of-state populations

Aroostook, Maine Overwintered adults were collected on 22 June 2012 by Andrei Alyokhin, University of Maine, from the Aroostook Research Farm near Presque Isle, ME.

Bridgewater, Maine Summer adults were collected on 6 August 2012 by Aaron Buzza, University of Maine, from an organic seed farm near Bridgewater, ME.

Jamesport, New York Overwintered adults were collected on 31 May 2012 by Sandra Menasha, Cornell Cooperative Extension, from a commercial potato field in Jamesport, Suffolk County, NY.

North Hampton, Virginia Summer adults were collected on 18 June 2012 by Adam Wimer, Virginia Polytechnic Institute and State University, from volunteer potatoes in a cotton field in North Hampton County, VA.

Painter, Virginia Summer adults were collected on 4 June 2012 by Adam Wimer, Virginia Polytechnic Institute and State Universiy, from untreated research plots at Virgina Polytechnic Institute and State University's Agricultural Research and Extension Center in Painter, VA

Laboratory strain

New Jersey Adults obtained in 2008 from the Phillip Alampi Beneficial Insects Rearing Laboratory, New Jersey Department of Agriculture and since reared at Michigan State University without contact to insecticides.

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

IMIDACLOPRID	LD_{50} (µg/beetle)	95% Confidence Intervals
Michigan populations		
Anderson Brothers Field 26	0.873	0.747 – 1.013
DuRussell	1.008	0.810 – 1.719
Greenville	0.959	0.846 – 1.090
MSU	0.195	0.147 – 0.299
Sackett Potatoes Field 9	0.946	0.626 – 1.347
Sackett Potatoes Field 26	0.814	0.720 – 0.925
Sackett Potatoes Field 153	3.164	2.566 – 3.897
Tuscola	0.675	*
Out-of-state populations		
Aroostook, Maine	0.595	0.407 – 1.332
Bridgewater, Maine	1.723	1.458 – 2.048
Jamesport, New York	11.570	6.357 – 30.550
North Hampton, Virginia	0.862	*
Painter, Virginia	0.210	0.141 – 0.516
Laboratory strain		
New Jersey	0.075	0.054 – 0.100
THIAMETHOXAM		
Michigan populations		
Anderson Brothers Field 26	0.374	*
Greenville	0.408	0.359 – 0.467
MSU	0.140	0.119 – 0.167
Sackett Potatoes Field 9	0.426	0.351 – 0.581
Sackett Potatoes Field 26	0.251	0.150 – 0.509
Sackett Potatoes Field 153	0.464	0.398 – 0.525
Tuscola	0.434	0.287 – 0.540
Out-of-state populations		
Aroostook, Maine	0.197	0.173 – 0.225
Bridgewater, Maine	0.598	0.338 – 1.440
Jamesport, New York	0.861	0.766 – 0.967
North Hampton, Virginia	0.276	0.221 – 0.324
Painter, Virginia	0.109	0.046 – 0.295
Laboratory strain		
New Jersey	0.090	0.078 – 0.104

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

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan State University AgBioResearch

Nitrogen Source and Rate Response for Michigan Potato Production

Kurt Steinke (ksteinke@msu.edu) and Andrew Chomas
Soil Fertility and Nutrient Management
Dept. of Plant, Soil, and Microbial Sciences, Michigan State University
East Lansing, MI 48824

Location: MSU Montcalm Research Farm	**Tillage**: Conventional
Planting Date: April 27, 2012 (Vinekill 8/24/12)	**Trt's**: See below
Soil Type: Loamy sand; 2.0 OM; 6.1 pH, 135 P, 157 K	**Population**: 34 in. rows, 11 in. spacing
Variety: FL 2137	**Replicated**: 4 replications

There continues to be a critical need to develop nutrient management strategies that maximize nutrient use efficiency yet simultaneously remain productive long term through incremental improvements in soil quality and disease suppression. Slow-release nitrogen fertilizers are a technology intended to improve N use efficiency by improving potato yields or reducing nitrogen rates. These products are often comprised of plastic, resin, or wax coatings surrounding pellets of urea and meter the release of N over time thus limiting the amount of N subject to environmental losses at any one time. Environmentally Smart Nitrogen or ESN® is one example of a polymer-coated (slow-release) N fertilizer. The benefits of utilizing a slow-release product may result in a decreased total number of N applications, reduced N rates, or grower reassurance that N remains available during adverse or inconsistent rainfall patterns, or allow N to remain available in sloping or pot-holed areas of the field. Studies on slow-release fertilizers have provided mixed results. Investigations have discovered both yield increases and decreases using slow-release nitrogen fertilizer as compared to soluble N sources such as urea. In some cases, slow-release fertilizers have been too slow in meeting plant N demand during the critical periods of the growing season. However other studies have seen substantial yield increases when field conditions were favorable for nitrate leaching. Due to the vast amounts of precipitation and diversity of site-specific field conditions encountered in Michigan, data on the rate and timing of slow-release nitrogen sources are required to best utilize and recommend this technology.

Interest in S applications has increased due to significantly reduced atmospheric deposition of S throughout the state. Sulfur application to potatoes has been suspected to reduce the occurrence of scab and may assist with other nutrient uptake. Ammonium sources of N, which can decrease soil pH upon plant uptake, may also reduce the occurrence of potato scab by inhibiting the fungal growth at lower soil pH levels. Ammonium sulfate nitrate (ASN) is a relatively new product that combines the agronomic attributes of ammonium sulfate and ammonium nitrate that can also be blended with urea. Sulfur fertilization has been shown to increase both total and marketable potato yields but data concerning the use of ASN are limited.

Materials and Methods.

Six treatments were arranged in a randomized complete block design with four replications. Individual plots measured 12 feet wide by 25 feet long and consisted of four potato rows spaced at 34 inches. ‘FL 2137’ variety tubers were planted on April 27, 2012 at an 11 inch spacing. Admire (imidacloprid) at 8 oz was applied at planting. Fungicides were applied throughout the season to maintain potato health. Manzate (mancozeb) and Tanos (fomoxadone + cymoxanil) were applied at 1.5 lbs/A and 8 fl oz/A, respectively on June 8. A tank mix of 2 pts/A Bravo (chlorothanlonil) and 8 fl oz/A Tanos was applied on June 18. Echo (chlorothanlonil) at 2 pts/A was applied on June 25. Bravo was applied at 2 pts/A on July 4, 12, 20, and 30. Manzate at 2 lbs/A, 1.9 lbs/A, and 2 lbs/A was applied on August 6, 14, and 20, respectively. Reglone (diquat) + NIS were applied as a potato desiccant on August 24, 2012 at 2 pts + ¼ % .

Three N sources and two N rates were tested in this field investigation including ESN, urea, and ammonium sulfate nitrate applied at 200 and 250 lbs. N/A. To initiate the N release process, ESN applications were applied with a one-time application at emergence as this product is thought to have a 60-80 day peak release window. Urea and ammonium sulfate nitrate applications were split applied with 1/3 total N at emergence and the remaining 2/3 total N at hilling. Starter fertilizer was pre-plant applied to all plots to provide 30, 50, and 150 lbs/A of N, P2O5, and K2O, respectfully.

Measureables.

- Total yield and specific gravity
- Petiole samples at 50 DAP and 80 DAP to determine total N status of plant
- SPAD chlorophyll readings at petiole sampling timings
- Soil sampling for nitrate-N analysis (50-60 DAP)
- Vine kill evaluation
- Disease evaluation (hollow heart, scab)

Treatments.

Trt.	N Source	Total N Rate (lb. N/A)	Timing
1	Check	---	---
2	ESN	200	Emergence
3	ESN	250	Emergence
4	Urea	200	1/3 Emergence 2/3 Hilling
5	Urea	250	1/3 Emergence 2/3 Hilling
6	ASN	200	1/3 Emergence 2/3 Hilling
7	ASN	250	1/3 Emergence 2/3 Hilling

Results.

Table 1. Effects of N source and N rate on SPAD chlorophyll measurements and petiole dry weight at 54 and 80 Days After Plant, Entrican, MI, 2012.

Treatment	Total N Rate (lb. N/A)	SPAD 54 DAP	SPAD 80 DAP	Petiole Dry Wt. 25 plants 54 DAP (grams)	Petiole Dry Wt. 25 plants 80 DAP (grams)
ESN	200	50.8 c	45.0 ab	11.1 a	4.0 b
ESN	250	51.2 bc	45.7 ab	11.9 a	4.7 ab
Urea	200	51.9 bc	44.4 b	12.6 a	4.9 ab
Urea	250	54.3 a	45.3 ab	11.3 a	4.2 ab
ASN	200	54.2 a	46.0 ab	12.5 a	5.1 a
ASN	250	52.6 ab	47.5 a	13.4 a	4.1 b

Different letters within a column denote statistically significant differences between treatment means ($P \leq 0.10$).

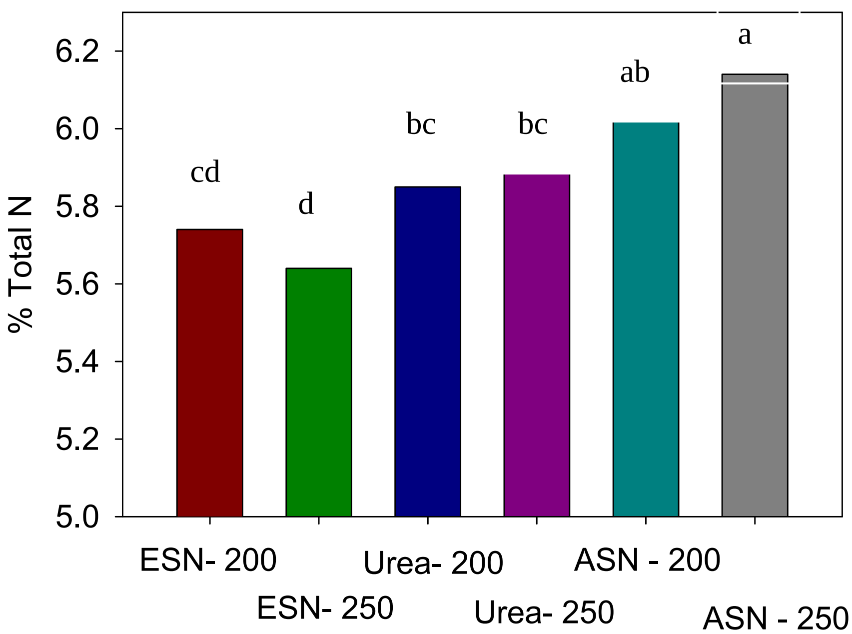


Figure 1. N source and N rate effects upon total tissue % N at 54 days after planting, Entrican, MI, 2012. Different letters above a column denote statistically significant differences between treatment means ($P \leq 0.10$).

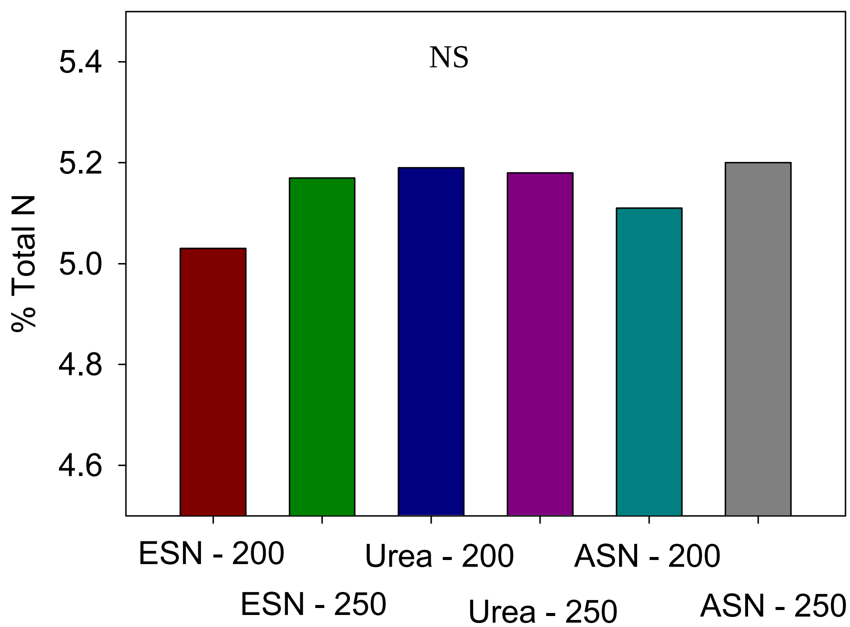


Figure 2. N source and N rate effects upon total tissue % N at 80 days after planting, Entrican, MI, 2012. Different letters above a column denote statistically significant differences between treatment means ($P \leq 0.10$).

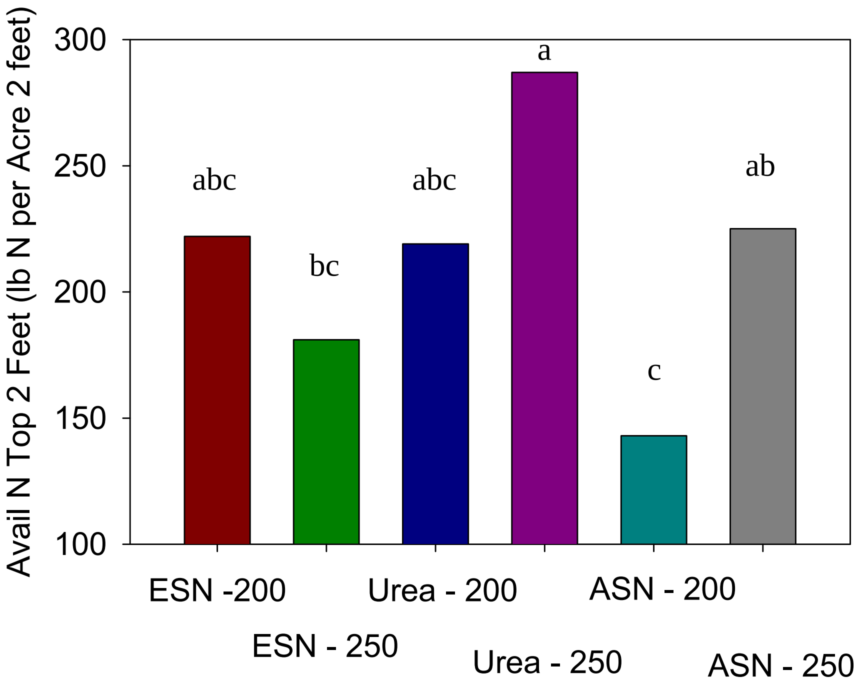


Figure 3. N source and N rate effects on soil residual N at 54 days after planting, Entrican, MI, 2012. Different letters above a column denote statistically significant differences between treatment means ($P \leq 0.10$).

Table 2. Effects of N source and N rate on SPAD chlorophyll measurements and petiole dry weight at 54 and 80 Days After Plant, Entrican, MI, 2012.

Treatment	Total N Rate (lb. N/A)	Total Yield (cwt/A)	Specific Gravity
ESN	200	393 ab	1.06 a
ESN	250	382 ab	1.07 a
Urea	200	385 ab	1.06 a
Urea	250	363 b	1.07 a
ASN	200	411 a	1.06 a
ASN	250	377 ab	1.07 a

Different letters within a column denote statistically significant differences between treatment means ($P \leq 0.10$).

Early season SPAD chlorophyll meter readings (Table 1) indicated that the ESN and low-rate urea applications were slightly reduced at 54DAP as compared to ASN and the high-rate urea treatments. However by 80 DAP, ESN applications attained similar and in some instances greater plant chlorophyll levels as compared to soluble N sources. This result has been typical with slow release N for potatoes in that ESN has been slow to enter the plant early in the season but chlorophyll levels do elevate mid- to late-season. The 250 N rate of ASN did result in the darkest plant at both 54 and 80 DAP. Petiole dry weights were not affected by N source early in the season and only displayed modest differences by mid-July. Incidence of potato scab and hollow heart were either non-existent or at minimally low numbers that statistics could not be run on these data.

Percent total tissue N followed a similar pattern as plant chlorophyll levels with ESN applications lagging early in the season but attaining similar tissue levels of N around 80 DAP (Fig. 1 and 2). ASN at both application rates appeared to increase tissue N to a greater extent than ESN or urea early in the season, but this result dissipated by 80 DAP. Applications of ASN seemed to promote a greener plant and greater levels of tissue N through the first 50-60 DAP. Residual soil N at 54 DAP was somewhat reduced with ASN due to 75% of this product comprised of ammonium-N whereas the ESN was reduced due to the slow-release nature of the product. Urea at 250 lbs N maintained greater soil N levels than the other products. Greater levels of mid-season soil N may make these products more vulnerable to environmental losses but there may also be a risk in insufficient soil N levels limiting yield potentials.

All 3 N sources provided greater yield at 200 lb N rates as compared to 250 lb N rates (Table 2). Average potato yields across N sources went as follows: ASN > ESN > Urea. ASN at 200 lb N/A was the only treatment to cross the 400 cwt threshold. Fears of a slow-release product such as ESN not maintaining season long available N seem to be unwarranted as yields from this product were greater than a soluble N source such as urea. The lack of early season N uptake from ESN-only applications may necessitate the blending of this product with a soluble N source such as urea. This practice of blending ESN with urea has been met with some degree of success in Michigan corn production. ESN seems to perform better the earlier it is applied in the season which may equate into all pre-plant N applications. ASN seems to perform well as a stand-alone N source but economics may also warrant the blending of this product with urea as a cost-effective control measure. Future work will continue focusing upon the economical use of newer fertilizer technologies including slow-release N and some of the newer S products as a means to cost effectively produce potatoes and simultaneously improve both potato and soil quality.

Impact of Organic and Inorganic Fertilizer Sources for Michigan Potato Production

Kurt Steinke (ksteinke@msu.edu) and Andrew Chomas
Soil Fertility and Nutrient Management
Dept. of Plant, Soil, and Microbial Sciences, Michigan State University
East Lansing, MI 48824

Location: MSU Montcalm Research Farm	**Tillage**: Conventional
Planting Date: April 27, 2012 (Vinekill 8/24/12)	**Trt's**: See below
Soil Type: Loamy sand; 2.0 OM; 6.2 pH, 151 P, 149 K	**Population**: 34 in. rows, 11 in. spacing
Variety: FL 2137	**Replicated**: 4 replications

Michigan has access to several locally available sources of organic fertilizers including compost, manure, and other soil amendments yet identifying a formal use or recommendation for these local source products remains elusive. Growers may utilize these products with the mindset that they are doing something positive for their operation. Often times however the nutrient value of these products may not be accounted for in the overall nutrient management program or little is understood on how effective these sources are individually or in combination with synthetic fertilizers. Additionally, a new modified organic product has come onto the market labeled as a complex nutrient enabling fertilizer. This product contains a mixture of macro- and micro-nutrients, amino acids, enzymes, vitamins, and mycorrhizal inoculants and is formulated similar to the nutrient composition of the soil microbial community instead of the nutrient needs of the plant. Data on the use of organic or organic-based fertilizers individually as compared to conventional nitrogen (N) sources for potato production in Michigan are limited.

Materials and Methods.

Six treatments were arranged in a randomized complete block design with four replications. Individual plots measured 12 feet wide by 25 feet long and consisted of four potato rows spaced at 34 inches. 'FL 2137' variety tubers were planted on April 27, 2012 at an 11 inch spacing. Admire (imidacloprid) at 8 oz was applied at planting. Fungicides were applied throughout the season to maintain potato health. Manzate (mancozeb) and Tanos (fomoxadone + cymoxanil) were applied at 1.5 lbs/A and 8 fl oz/A, respectively on June 8. A tank mix of 2 pts/A Bravo (chlorothanlonil) and 8 fl oz/A Tanos was applied on June 18. Echo (chlorothanlonil) at 2 pts/A was applied on June 25. Bravo was applied at 2 pts/A on July 4, 12, 20, and 30. Manzate at 2 lbs/A, 1.9 lbs/A, and 2 lbs/A was applied on August 6, 14, and 20, respectively. Reglone (diquat) + NIS were applied as a potato desiccant on August 24, 2012 at 2 pts + ¼ % .

Three fertilizer products including Perfect Blend® poultry fertilizer (8-5-5), Herbrucks Poultry Ranch® pelletized poultry fertilizer (4-3-2), and a conventional synthetic nitrogen fertilizer program were tested in this field investigation. All organic applications and starter fertilizer for the conventional N treatment were applied pre-plant incorporated.

Due to large organic N contributions at rates used in this study, nitrogen was equalized among all treatments at a rate of 300 lbs./A. Organic fertilizer treatments functioned under the assigned constant that 67%, 60%, 80%, and 55% of organic N, P, K, and S would mineralize during year one. For the conventional N program, P, K. and S were applied at balanced rates to the equivalent year one mineralization contributions of these nutrients from the organic treatments. The starter fertilizer for the conventional N treatment consisted of 30 lbs. N, 50 lbs. P2O5, 150 lbs K2O, and 60 lbs. S/A. The conventional N treatment consisted of applying 1/3 remaining total N as ammonium sulfate at emergence and 2/3 remaining total N as ammonium sulfate nitrate at hilling.

Measureables.

- Greenseeker chlorophyll readings (40 days after emergence)
- Petiole dry weight and total N analysis at 54 days after planting
- Disease evaluation (hollow heart, scab)
- Total yield and specific gravity

Treatments.

Product	Rate	1st Yr. Available Organic N (lb/A)	Supplemental Inorganic N (lb/A)†	Total N (lb. N/A)
Check	---	---	0	0
Perfect Blend (8-5-5)	1.0 T/A	107	193	300
Perfect Blend (8-5-5)	2.5 T/A	268	32	300
Herbruck's (4-3-2)	1.0 T/A	54	246	300
Herbruck's (4-3-2)	2.5 T/A	134	166	300
Conventional N Program‡	1/3 emergence 2/3 hilling	----	300	300

† Supplemental inorganic N treatments consisted of applying 1/3 remaining total N as ammonium sulfate at emergence and 2/3 remaining total N as ammonium sulfate nitrate at hilling.

‡ Conventional N treatment received starter fertilizer consisting of 30 lbs. N, 50 lbs. P2O5, 150 lbs K2O, and 60 lbs. S/A to balance these nutrients with organic source nutrient contributions.

Results.

Table 1. Effects of organic and inorganic N sources on leaf reflectance, petiole weight, and tissue % total N at 54 days after planting, Entrican, MI, 2012.

Treatment	Rate	Greenseeker (NDVI)	Petiole Dry Wt. 25 plants (grams)	% Total N
Perfect Blend (8-5-5)	1.0 T/A	0.80 a	9.4 a	6.6 a
Perfect Blend (8-5-5)	2.5 T/A	0.73 b	10.8 a	6.5 a
Herbruck's (4-3-2)	1.0 T/A	0.78 a	8.3 a	6.7 a
Herbruck's (4-3-2)	2.5 T/A	0.77 ab	8.4 a	6.6 a
Conventional N Program	1/3 emergence 2/3 hilling	0.79 a	8.2 a	6.5 a

Different letters within a column denote statistically significant differences between treatment means ($P \leq 0.10$).

Table 2. Effects of organic and inorganic N sources on total yield, and specific gravity, Entrican, MI, 2012.

Treatment	Rate	Total Yield (cwt/A)	Specific Gravity
Perfect Blend (8-5-5)	1.0 T/A	381 a	1.07 a
Perfect Blend (8-5-5)	2.5 T/A	395 a	1.07 a
Herbruck's (4-3-2)	1.0 T/A	370 a	1.07 a
Herbruck's (4-3-2)	2.5 T/A	369 a	1.08 a
Conventional N Program	1/3 emergence 2/3 hilling	375 a	1.07 a

Different letters within a column denote statistically significant differences between treatment means ($P \leq 0.10$).

Early planting date and warm dry 2012 growing conditions proved challenging in controlling disease, but concerns over these conditions impacting potato yields were not realized as production was much less affected than researchers previously thought going into the harvest season. At 54 days after planting, few differences were evident in plant color, dry weight of petioles, or % total tissue N (Table 1). Total potato yields and specific gravities proved non-significant amongst the treatments (Table 2). Incidence of potato scab and hollow heart were either non-existent or at minimally low numbers that statistics could not be run on these data.

Despite many of the measureables resulting in non-significant responses, we can use these data to begin to adapt alternative N sources into potato management programs. Fears of early applications of organic-based N sources limiting early-season plant growth and ultimately yield were not warranted as plant color, petiole weights, and tissue analysis proved similar and in many cases greater than the conventional N program. Total potato yields were statistically similar between all treatments. The lack of yield differences amongst treatments indicates that providing an up-front N source that is *not* 100% water soluble does not sacrifice yield potential. Despite the organic N treatments receiving supplemental N later in the season, the 2.5 T rate of these products received much reduced rates of supplemental synthetic N yet produced competitive yields. These results may indicate that a factor beyond the nutrition value of the product is affecting production (e.g., slower nutrient release, soil microbial status, etc.). Future work will continue focusing upon organically-based N sources both individually and with supplemental N and determining impacts on soil health including soil micro- and macro-fauna.

Funding: MPIC and Industry

Seed treatments and seed plus in furrow treatments for control of seed- and soil-borne *Rhizoctonia solani*, 2012.

W. W. Kirk, R. L Schafer and A. Merlington; Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824

Potatoes with *Rhizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potato seed (Russet Norkotah) was prepared for planting by cutting and treating with fungicidal seed treatments two days prior to planting. Seed were planted at the Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 17 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a 5-ft unplanted alley. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for 2 min to ensure even spread of the fungicide. Potato seed liquid treatments were applied in water suspension at a rate of 0.2 pt/cwt onto the exposed seed tuber surfaces in the Gustafson seed treater. In-furrow at-planting applications were delivered in 8 pt water/A in a 7 in. band using a single XR11003VS nozzle at 30 psi. Foliar applications were applied with a R&D spray boom delivering 25 gal/A (80 psi) 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 N 6SC was applied at 0.7 pt/A on a seven-day interval, total of four applications, starting one day after inoculation of adjacent plots with *Phytophthora infestans* to prevent spread of potato late blight. Weeds were controlled by hilling and with Dual 8E at 2 pt/A 10 DAP and Poast 1.5EC at 1.5 pt/A 58 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Plant stand was rated 21, 25 and 33 days after planting (DAP) and relative rate of emergence was calculated as the Relative Area Under the Emergence Progress Curve [RAUEPC from 0 – 33 DAP, maximum value = 100]. Plots were harvested on 27 Sep and individual treatments were weighed and graded. Four plants per plot were harvested 36 days after planting (20 Jun) and the percentage of stems and stolons with greater than 5% of the total surface area affected were counted. Samples of 20 tubers per plot were stored for 22 days after harvest in the dark at 50^{o}F and assessed for black scurf (*R. solani*) incidence (%) and severity. Severity of black scurf was measured as an index calculated by counting the number of tubers (n = 20) falling into each class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15; 4 >15% surface area of tuber covered with sclerotia. The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as a percentage. Indices of 0 - 25 represent 0 - 5%; 26 - 50 represent 6 - 10%; 51 - 75 represent 11 - 15% and 75 - 100 >15% surface area covered with sclerotia. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Oct. Average daily air temperatures (^{o}F) were 60.9, 69.5, 75.6, 68.2, 60.1 and 49.2 (May – Oct) with 1, 2, 15, 3, 0 and 0-d with maximum temperature >90^{o}F (May – Oct). Average daily soil moisture was 18.5, 14.9, 11.1, 13.1, 10.8 and 14.7 (% of field capacity at 2" depth; May – Oct) and 19.9, 14.3, 9.9,13.0,10.1 and 14.6 (% of field capacity at 4" depth; May – Oct). Average daily soil temperature was 60.4, 69.8, 76.5, 68.1, 61.7 and 50.9 at 2" depth (May – Oct) and 62.3, 72.1, 78.1, 68.9, 62.3, and 50.8 at 4" depth (May – Oct). Precipitation was 0.98, 0.99, 3.63, 3.31, 0.76 and 5.38 in. (May – Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4-d period with overhead pivot irrigation.

Treatments with final plant stand greater than 91.5% were significantly higher in comparison to the untreated control (83.0%). No other treatment affected final plant stand in comparison to the untreated control. Treatments with relative rate of emergence (RAUEPC) greater than 48.8 were significantly higher in comparison to the untreated control (42.9). No other treatment affected RAUEPC in comparison to the untreated control. Treatments with total yield greater than 242 cwt/A had significantly higher yield than the untreated control. Treatments with final stem number greater than 5.0 were significantly higher in comparison to the untreated control (3.6 stems/plant). No other treatment affected stem number/plant in comparison to the untreated control. Treatments with less than 77.2% incidence of stems with stem canker with greater than 5% of the total surface area affected had significantly less stem canker than the untreated check (96.9%). No treatments had significantly different number of stolons per plant from the untreated control (10.1 stolons/plant). Treatments with less than 27.7% incidence of stolons with stem canker with greater than 5% of the total surface area affected had significantly less stolon canker than the untreated check (56.7%). Treatments with less than 58.8% incidence of tuber black scurf had significantly less black scurf than the untreated check (78.8%). Treatments with less than 23.8 severity index of tuber black scurf less than in comparison to the untreated check (35.8%). Seed treatments were not phytotoxic.

Treatment and rate/cwt potato seed (A); rate/1000 row feet (B); foliar rate/A	Final plant stand (%)		RAUEPC[a]		Total Yield (cwt/A)	
Serenade Soil 1.34SC 4.4 fl oz (B[b])………	93.5	ab[c]	48.8	abc	278	abc
Quadris 2.08SC 250SC 0.96 fl oz (B)…….	88.0	a-d	46.4	abc	234	b-f
CR-9032 100L 1.84 fl oz (B); 1 pt/A (C)…	88.5	a-d	45.5	abc	242	a-f
CR-9032 100L 3.67 fl oz (B); 2 pt/A (C)…	86.0	a-d	42.4	bc	233	b-f
Vertisan 1.67EC 0.7 fl oz (B)……………..	88.0	a-d	51.0	ab	246	a-e
Vydate 3.77SL 3.86 fl oz (B)……………..	86.0	a-d	41.6	bc	275	abc
Vydate 3.77SL 7.7 fl oz (B)………………	89.5	a-d	43.8	bc	201	d-g
Vertisan 1.67EC 0.7 fl oz + Vydate 3.77SL 3.86 fl oz (B)……………..	82.5	d	44.1	bc	216	def
Vertisan 1.67EC 0.7 fl oz + Vydate 3.77SL 7.7 fl oz (B)………………	85.0	a-d	40.6	c	196	efg
Fontelis 1.67SC 0.3 fl oz/cwt (A); Vertisan 1.67EC 0.7 fl oz (B)…………….	90.0	a-d	41.5	bc	207	d-g
Quadris 2.08SC 250SC 0.6 fl oz (B)……..	84.0	bcd	39.8	c	229	b-f
Vertisan 1.67EC 1.15 fl oz (B)……………	89.0	a-d	47.2	abc	160	g
Vertisan 1.67EC 1.6 fl oz (B); Vertisan 1.67EC 24 fl oz/A (C,D)………...	90.5	a-d	43.2	bc	237	b-f
Fontelis 1.67SC 0.15 fl oz/cwt + Manzate 4F 0.9 fl oz/cwt (A)……………..	92.5	abc	54.1	a	227	c-f
Fontelis 1.67SC 0.3 fl oz/cwt + Manzate 4F 0.9 fl oz/cwt (A)……………..	87.5	a-d	45.0	abc	271	abc
Quadris 2.08SC 250SC 0.8 fl oz (B)……...	82.5	d	43.0	bc	208	d-g
Maxim MZ 6.2DS 8 oz wt/cwt (A)……….	90.5	a-d	47.3	abc	226	c-f
MBI-106020 20SC 0.5 fl oz (B)…………..	93.0	ab	45.3	abc	253	a-d
MBI-106020 20SC 1 fl oz (B)…………….	93.0	ab	50.8	ab	216	def
MBI-106020 20SC 2 fl oz (B)…………….	91.5	a-d	46.6	abc	281	ab
MBI-106020 20SC 4 fl oz (B)…………….	91.0	a-d	45.7	abc	272	abc
MBI-106020 20SC 1 fl oz + Moncut 70DF 1.1 oz (B)………………….	90.0	a-d	50.5	ab	293	a
MBI-106020 20SC 1 fl oz + Quadris 2.08SC 250SC 0.8 fl oz (B)……...	88.0	a-d	43.5	bc	216	def
ActinoGrow 0.0371WP 0.46 oz (B)………	94.5	a	54.5	a	227	c-f
ActinoGrow 0.0371WP 0.69 oz (B)………	87.0	a-d	45.4	abc	210	d-g
WE1042-2 70DS 1 lb/cwt (A)…………….	91.0	a-d	46.6	abc	252	a-d
WE1043-1 70DS 1 lb/cwt (A)…………….	93.5	ab	44.8	abc	227	c-f
WE1224-1 70DS 1 lb/cwt (A)…………….	93.5	ab	48.1	abc	228	c-f
WE1044-1 70DS 1 lb/cwt (A)…………….	85.5	a-d	41.5	bc	226	c-f
Maxim 4FS 4FS 0.08 fl oz/cwt + WE1042-2 70DS 1 lb/cwt (A)…………….	91.0	a-d	45.3	abc	232	b-f
Untreated Check…………………………..	83.0	cd	42.9	bc	193	fg

Funding: MPIC and Industry

Treatment and rate/cwt potato seed (A); rate/1000 row feet (B); foliar rate/A	Stems (31 DAP) Number	Stems (31 DAP) Percent infected[d]	Stolons (31 DAP) No./plant	Stolons (31 DAP) Girdling[e] > 5%	Tuber black scurf Incidence (%)	Tuber black scurf Severity scale (0 - 100)
Serenade Soil 1.34SC 4.4 fl oz (B[b])………	3.5 bc	83.1 ab	10.5 a-d	27.7 de	38.8 fg	16.0 gh
Quadris 2.08SC 250SC 0.96 fl oz (B)…….	7.1 a	78.9 ab	10.4 a-d	52.2 a-d	60.0 b-g	23.8 a-h
CR-9032 100L 1.84 fl oz (B); 1 pt/A (C)…	3.9 bc	87.9 ab	12.3 abc	44.5 a-e	77.5 abc	31.8 a-e
CR-9032 100L 3.67 fl oz (B); 2 pt/A (C)…	4.8 abc	86.3 ab	12.5 abc	34.3 cde	65.0 a-e	21.8 c-h
Vertisan 1.67EC 0.7 fl oz (B)……………..	4.1 bc	77.9 ab	10.1 a-d	41.8 a-e	42.5 efg	15.3 gh
Vydate 3.77SL 3.86 fl oz (B)……………..	3.5 bc	83.3 ab	8.5 bcd	40.0 a-e	36.3 g	11.5 h
Vydate 3.77SL 7.7 fl oz (B)………………	2.5 c	100 a	11.1 a-d	56.1 a-d	48.8 d-g	20.0 e-h
Vertisan 1.67EC 0.7 fl oz + Vydate 3.77SL 3.86 fl oz (B)……………..	3.6 bc	93.3 a	7.6 cd	56.4 a-d	43.8 efg	12.3 h
Vertisan 1.67EC 0.7 fl oz + Vydate 3.77SL 7.7 fl oz (B)………………	3.5 bc	98.2 a	10.3 a-d	55.1 a-d	78.8 ab	28.5 a-f
Fontelis 1.67SC 0.3 fl oz/cwt (A); Vertisan 1.67EC 0.7 fl oz (B)…………….	3.6 bc	80.0 ab	13.4 ab	40.9 a-e	82.5 ab	33.3 a-d
Quadris 2.08SC 250SC 0.6 fl oz (B)……..	4.4 bc	77.2 ab	10.8 a-d	37.7 b-e	58.8 b-g	25.8 a-g
Vertisan 1.67EC 1.15 fl oz (B)……………	2.9 bc	97.5 a	12.5 abc	56.7 a-d	63.8 a-e	19.8 e-h
Vertisan 1.67EC 1.6 fl oz (B); Vertisan 1.67EC 24 fl oz/A (C,D)………..	3.1 bc	92.7 a	10.9 a-d	46.7 a-e	45.0 efg	16.3 fgh
Fontelis 1.67SC 0.15 fl oz/cwt + Manzate 4F 0.9 fl oz/cwt (A)……………..	3.4 bc	94.4 a	11.1 a-d	44.7 a-e	47.5 d-g	17.0 fgh
Fontelis 1.67SC 0.3 fl oz/cwt + Manzate 4F 0.9 fl oz/cwt (A)……………..	3.0 bc	95.8 a	10.3 a-d	66.7 ab	63.8 a-e	23.3 b-h
Quadris 2.08SC 250SC 0.8 fl oz (B)……..	4.3 bc	82.8 ab	7.1 d	35.7 cde	87.5 a	34.0 abc
Maxim MZ 6.2DS 8 oz wt/cwt (A)……….	3.6 bc	91.7 a	9.6 a-d	46.6 a-e	63.8 a-e	21.3 d-h
MBI-106020 20SC 0.5 fl oz (B)…………..	3.0 bc	95.8 a	9.4 a-d	69.6 a	61.3 b-f	23.0 b-h
MBI-106020 20SC 1 fl oz (B)…………….	4.4 bc	92.9 a	13.0 ab	53.7 a-d	71.3 a-d	23.8 a-h
MBI-106020 20SC 2 fl oz (B)…………….	5.0 ab	88.8 ab	11.8 a-d	39.7 a-e	78.8 ab	35.3 ab
MBI-106020 20SC 4 fl oz (B)…………….	3.8 bc	96.9 a	10.0 a-d	69.6 a	76.3 abc	34.3 ab
MBI-106020 20SC 1 fl oz + Moncut 70DF 1.1 oz (B)………………….	3.0 bc	88.1 ab	10.9 a-d	49.5 a-e	50.0 d-g	21.5 d-h
MBI-106020 20SC 1 fl oz + Quadris 2.08SC 250SC 0.8 fl oz (B)……..	4.3 bc	68.1 b	9.8 a-d	19.2 e	61.3 b-f	18.5 fgh
ActinoGrow 0.0371WP 0.46 oz (B)………	3.9 bc	93.8 a	13.9 a	52.9 a-d	71.3 a-d	25.8 a-g
ActinoGrow 0.0371WP 0.69 oz (B)………	3.9 bc	85.0 ab	8.9 a-d	45.0 a-e	53.8 c-g	20.8 e-h
WE1042-2 70DS 1 lb/cwt (A)…………….	3.5 bc	89.5 ab	11.1 a-d	39.5 a-e	45.0 efg	15.0 gh
WE1043-1 70DS 1 lb/cwt (A)…………….	4.0 bc	93.8 a	11.3 a-d	56.9 a-d	46.3 efg	15.3 gh
WE1224-1 70DS 1 lb/cwt (A)…………….	3.8 bc	88.5 ab	10.1 a-d	47.9 a-e	45.0 efg	15.5 gh
WE1044-1 70DS 1 lb/cwt (A)…………….	3.0 bc	96.9 a	8.6 bcd	49.2 a-e	46.3 efg	19.3 fgh
Maxim 4FS 4FS 0.08 fl oz/cwt + WE1042-2 70DS 1 lb/cwt (A)…………….	3.8 bc	86.5 ab	11.0 a-d	59.5 abc	58.8 b-g	20.0 e-h
Untreated Check…………………………..	3.6 bc	96.9 a	10.1 a-d	56.7 a-d	78.8 ab	35.8 a

[a] RAUEPC = Relative area under the emergence progress curve measured from planting to 31 days after planting.
[b] Application dates: A= 15 May (liquid formulations for seed piece application at 0.2 pt/cwt); B= 17 May (in-furrow); C= 8 Jun (foliar); D= 23 Aug (foliar).
[c] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).
[d] Stems with greater than 5% of area with stem canker due to *Rhizoctonia solani.*
[e] Stolons with greater than 5% of area with stolon canker due to *Rhizoctonia solani.*

Funding: MPIC and Industry

Seed treatments, in furrow and early foliar treatments for control of seed-borne *Phytophthora infestans* (US-22), 2012.

S. Dangi, W. W. Kirk, P. Somohano and R. L. Schafer. Department of Plant, Soil and Microbial Science. MSU. East Lansing, MI 48824.

INTRODUCTION:

Late blight (*Phytophthora infestans*) is a major constraint worldwide in the production of high quality potatoes and billions of dollars are expended annually in the management of the disease (Fry and Goodwin 1997; Forbes, et al., 1998). Oospores, infected seed tubers, cull piles and infected volunteer tubers all have been reported as the overwintering stages and primary sources of inoculum epidemic initiation (Fernandez-Pavia et al., 2004; Zwankhuizen et al., 1998; Kirk et al., 2003). However, in North America, the main source of inoculum is thought to be infected tubers for overwintering and transmission of disease to healthy plants (Johnson, 2010). The infection of tubers with *P. infestans* can be in the field during growing season, at harvest, and during the seed handling operation (Lambert et al. 1998). Infected seed tubers may rot in storage or after planting, but can initiate an epidemic if the pathogen survives within the young host plant (Kirk et al., 2009) however little is known of this process for biotypes of *P. infestans* such as US-22 that recently appeared in North America. Therefore, it is important to treat seed tubers with effective fungicides before planting. Studies have shown that foliar fungicides of *P. infestans* are not effective as a seed tuber treatment though cymoxanil + mancozeb (Curzate M-8) which has protectant and limited systemic activity were somewhat effective in protecting both tuber surface and sprouts (Inglis et al. 1999). Risk of blight spreading from infected seed tuber to sprout and ultimately to foliage may increase in pre-cutting and seed treatments. Fungicides with systemic and non-systemic components when treated in combination such as thiophanate-methyl + mancozeb + cymoxanil suppressed the development of late blight in newly emerged plants (Kirk et al., 1999). In a study Thiophanate-methyl + mancozeb applied to blighted seed pieces did not improve emergence but when seed was pre-treated prior to inoculation seed emergence was improved (Inglis et al., 1999). This result suggests that performance of fungicides against *P. infestans* during handling operations of potato seed piece may be more beneficial than used curative applications. Biotypes of *P. infestans* that have recently appeared in North America are more sensitive to the phenylamide fungicide metalaxyl, than the insensitive biotypes common up to 2009 (Hu et al., 2012). The objectives of this study therefore were to study the effect of timing of crop protection activities in relation to seed cutting, sprout development and time of planting for the successful management of late blight. The specific objectives of this study were to determine (i) effectiveness of different fungicides to control seed borne *P. infestans* applied as seed treatments or in furrow during planting and after emergence and ii) to determine the impact of fungicides applied alone or as combinations.

MATERIALS AND METHODS:

Inoculum: Multiple isolates of *P infestans* US-22 genotype (A_2 mating type, sensitive to mefenoxam) from potato and tomato were used in this study. Isolates were grown on Rye B media and detached tomato leaves in rectangular plastic boxes lined with moistened paper towels and incubated at 18°C. Culture plates (9 cm diameter x 15 mm depth Petri plates) were flooded and dislodged the mycelia with 50ml sterile distilled water and tomato leaves were washed with the sterile distilled water 12 days after inoculation to release sporangia. The final concentration of inoculum was adjusted to 10^5 - 10^6 sporangia ml^{-1}. The suspension was placed at 4°C for 2 hours to release the zoospores. Potato seed (Snowden) were first cut into two or three sections (based on size of potato) longitudinally ensuring the presence of viable sprouts on each seed-piece. The cut seed pieces were immersed in the mixture of mycelium and zoospores of *P. infestans* for 30 minutes then dried at 18^{o}C for 1 h prior to treating with fungicidal seed treatments on the same day of planting.

Fungicides: Ten different fungicides with different concentrations (some treated alone and some in combination) were used in the study (Tables 1 - 3). The samples for each treatment consisted of 320 seed pieces that were treated with each fungicide/combination per treatment or left untreated for foliar applied and non-treated combinations. The treated tubers were split into groups of 50 for 6 replications for the field experiment and 20 tubers were sampled for determination of inoculation efficiency in controlled environment chambers. Dust formulations were measured and added to inoculated seed pieces in a plastic or paper bags and shaken for 2 min to ensure uniform spread of the fungicide until the fungicides were coated on the seed. Fungicides applied as pre-planting potato seed liquid treatments were applied in water suspension at a rate of 0.2 pt H_2O/cwt onto the exposed seed tuber surfaces, with the entire seed surface being coated in the Gustafson seed treater. In-furrow at-planting applications were delivered at 8 pt water/A in a 7 in. band using a single XR11003VS nozzle at 30 p.s.i. Foliar applications were applied with a R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row.

Laboratory experiment: 20 potato seed pieces from each treatment were harvested in 5lb mesh bags and incubated in plastic boxes lined with wet paper towels at 15°C in environmental control chamber for 30 days. After incubation disease incidence was evaluated.

Field experiment: Seed were planted at the Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 13 June 2012 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 six times in a randomized complete block design. The two-row beds were separated by a 5-ft unplanted 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 and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire Pro 2F at 1.25 pt/A at planting (if not already included as a seed treatment), 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. Meteorological variables were measured with a Campbell weather station located at the farm from 1 June to harvest
(16 Oct.). Average daily air temperature (^{o}F) from 1 June was 67.0, 76.2, 68.0 and 59.7 and the number of days with maximum temperature >90^{o}F was 3, 11, 2 and 0 (Jun, Jul, Aug and Sep, respectively). Average daily relative humidity (%) over the same period was 61.3, 64, 68.9 and 66.1 (Jun, Jul, Aug and Sep, respectively). Average daily soil temperature at 4” depth (^{o}F) over the same period was 73.1, 84.8, 72.3 and 64.9 and the number of days with maximum soil temperature >90^{o}F was 5, 19, 0 and 0 (Jun, Jul, Aug and Sep, respectively). Average daily soil moisture at 4” depth (% of field capacity) over the same period was 26.6, 32.1, 35.5 and 25.5 (Jun, Jul, Aug and Sep, respectively). Precipitation was 1.78, 3.17, 3.82 and 1.07 in (Jun, Jul, Aug and Sep, respectively). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

Data Analysis: The number of emerged plants was recorded over a 42-day period after planting and final plant stand (%) and the relative area under the emergence progress curve (RAUEPC) was calculated. The RAUEPC was calculated by dividing the AUEPC by the maximum AUEPC (100 X duration of emergence period) from planting to full emergence. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Plots (25-ft row) were harvested on 16 Oct and individual treatments were weighed, graded and final yield per treatment was determined. Data were analyzed using ARM 8.0 (Gylling Data Management, SD) by analysis of variance, and mean separation tests conducted with Fishers LSD method at $P \leq 0.05$.

RESULT AND DISCUSSION

Lab experiment: Late blight developed successfully in all the replications of the inoculated untreated check seed pieces. Late blight and other diseases did not develop in non-inoculated untreated check seed pieces. Seed pieces treated with different fungicides developed late blight in some tubers in all treatments (Table 1). Treatment with disease incidence greater than 30% were not significantly different from inoculated check (70%). This study was done to check the efficacy of the inoculation.

Field experiment: Late blight developed in the seed pieces and affected plant stands in all treatments. Responses of some treatments considered relative to the non-inoculated untreated check indicated that some treatments enhanced emergence rate. At the final plant stand evaluation, all treatments except the foliar application of Ridomil Gold Bravo had significantly greater plant stand in comparison to the inoculated check treatment. Treatments with greater than 70.1, 70.1 to 81.9, 66.4 to 77.8 and 44.1 to 49.7% plant stand were not significantly different from each other. Emergence taken over a 42 d period (RAUEPC) indicated that treatments with RAUEPC value 18.6 were not significantly different from the inoculated check (RAUEPC =14.7). Treatments with RAUEPC values from 41.2 to 47.6, 34.4 to 42.3 and 18.6 to 26.1 were not significantly different. All treatments except the foliar application of Ridomil Gold Bravo had significantly greater plant stand in comparison to the inoculated check treatment. Late blight symptoms did not appear on stems or foliage in any treatment. Yield was drastically affected by inoculation and treatments with US1or total yield greater than 201 or 294 cwt/A were significantly different from the inoculated control and treatments with greater than 201 or 294 cwt/A, respectively were not significantly different from the non-inoculated control. Seed treatments and in-furrow applications of fungicides were not phytotoxic.

Funding: MPIC and Industry

Table 1. Effect of seed treatments, in furrow and early foliar treatments for control of seed-borne *Phytophthora infestans* (US-22) on disease incidence in inoculated tubers (%).

Treatment and rate/1000 row feet; Rate/cwt potato seed; and rate/A	Disease Incidence %[a]	
Revus 250SC 0.307 fl (A)………...…..	45	ab[b]
Revus 250SC 0.614 fl oz (A)…………..	40	ab
Revus 250SC 0.307 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	15	bc
Revus 250SC 0.614 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	35	abc
Moncoat MZ 7.5DP 12 oz (A)…………	20	bc
Maxim MZ 6.2DP 0.5 lb (A)…………..	30	bc
Curzate 60DF 1 oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	20	bc
WE1135-1 6DS 1 lb (A)……………….	25	bc
WE1043-1 6DS 1 lb (A)……………….	15	bc
Untreated Not-inoculated check……….	0	c
Inoculated Check………………………	70	a

[a] Disease incidence (%) is calculated as the ratio of tubers developing late blight symptoms. 20 potato seed pieces were harvested and incubated in plastic boxes lined with wet paper towels at 15°C in a controlled environmental chamber for 30 d.
Application dates: A=13 June (liquid formulations for seed piece application at 0.2 pt H_2O/cwt); A=13 June (dry formulation); B= 13 June (in-furrow).
Note: Treatment Ridomil Gold Bravo (foliar application) was excluded in the lab experiment.
[b] Values followed by the same letter are not significantly different at $p = 0.05$ (Least Square Means Tukey HSD).

Table 2. Effect of seed treatments, in furrow and early foliar treatments for control of seed-borne *Phytophthora infestans* (US-22), 2012 on plant stand (%), relative area under emergence progressive curve values (RAUEPC; 0 - 100).

Treatment and rate/1000 row feet; Rate/cwt potato seed; and rate/A	Plant Stand % 26 June 13 DAP[a]		2 July 19 DAP		9 July 26 DAP		18 July 35 DAP		25 July 42 DAP		RAUEPC[b] 42 DAP	
Ridomil Gold 4SL 0.42 fl oz (B[c])….......	19.7	b-e[d]	55.3	bc	60.3	b	65.7	d	66.4	c	35.7	b
Revus 250SC 0.307 fl (A)………..........	17.0	c-f	35.3	e	43.0	c	47.3	e	49.7	d	26.1	c
Revus 250SC 0.614 fl oz (A)…………	13.0	def	39.3	de	42.0	c	44.0	ef	44.1	de	24.4	c
Revus 250SC 0.307 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	17.7	cde	68.7	ab	75.7	a	80.0	abc	81.9	ab	42.3	ab
Revus 250SC 0.614 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	14.0	def	57.0	abc	63.7	ab	68.7	cd	70.1	bc	35.5	b
Moncoat MZ 7.5DP 12 oz (A)………...	32.7	a	72.0	a	75.3	a	83.7	ab	84.8	a	47.6	a
Maxim MZ 6.2DP 0.5 lb (A)…………..	17.0	c-f	53.0	cd	60.0	b	64.3	d	67.0	c	34.4	b
Curzate 60DF 1 oz (A) + Nubark Mancozeb 6DS 1 lb (A)……….	28.0	ab	63.7	abc	66.3	ab	73.0	bcd	75.4	abc	41.7	ab
WE1135-1 6DS 1 lb (A)……………….	23.0	a-d	64.0	abc	68.7	ab	75.3	a-d	77.8	abc	41.2	ab
WE1043-1 6DS 1 lb (A)……………….	28.0	ab	68.0	abc	75.3	a	85.7	a	86.1	a	46.3	a
Ridomil Gold Bravo 76.5WP 2 lb/A (C)	12.3	ef	26.0	ef	30.7	cd	33.7	fg	33.7	ef	18.6	cd
Untreated Not-inoculated check……….	26.7	abc	61.7	abc	65.3	ab	75.3	a-d	76.0	abc	41.3	ab
Inoculated Check……………………	7.0	f	17.3	f	27.0	d	30.0	g	29.8	f	14.7	d

[a] DAP= days after planting
[b] RAUEPC = Relative area under the emergence progress curve measured from planting to 42 days after planting
[c] Application dates: A=13 June (liquid formulations for seed piece application at 0.2 pt H_2O/cwt); A=13 June (dry formulation); B= 13 June (in-furrow); C= 13 July (foliar application)
[d] Values followed by the same letter are not significantly different at $p = 0.05$ (Least Significant Difference; Fischer Multiple Comparison)

Funding: MPIC and Industry

Table 3. Effect of seed treatments, in furrow and early foliar treatments for control of seed-borne *Phytophthora infestans* (US-22), 2012 on yield.

Treatment and rate/1000 row feet; Rate/cwt potato seed; and rate/A	Yield (cwt/A) US-1		Total	
Ridomil Gold 4SL 0.42 fl oz (B[a])….........	199	c[b]	291	cd
Revus 250SC 0.307 fl (A)………...……..	201	c	294	cd
Revus 250SC 0.614 fl oz (A)……………	172	cd	278	d
Revus 250SC 0.307 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)………...	272	ab	366	a
Revus 250SC 0.614 fl oz (A) + Nubark Mancozeb 6DS 1 lb (A)………...	238	b	327	bc
Moncoat MZ 7.5DP 12 oz (A)…………..	248	b	360	ab
Maxim MZ 6.2DP 0.5 lb (A)……….......	249	b	348	ab
Curzate 60DF 1 oz (A) + Nubark Mancozeb 6DS 1 lb (A)………...	243	b	348	ab
WE1135-1 6DS 1 lb (A)…………….	250	b	348	ab
WE1043-1 6DS 1 lb (A)………………...	289	a	385	a
Ridomil Gold Bravo 76.5WP 2 lb/A (C)..	162	d	265	d
Untreated Not-inoculated check……….	265	ab	359	ab
Inoculated Check………………………..	176	cd	283	d

[a] Application dates: A=13 June (liquid formulations for seed piece application at 0.2 pt H_2O/cwt); A=13 June (dry formulation); B= 13 June (in-furrow); C= 25 July (foliar application)
[b] Values followed by the same letter are not significantly different at $p = 0.05$ (Least Significant Difference; Fischer Multiple Comparison)

References:

Fernandez-Pavia, S.P. Grunwald, N.J. Diaz-Valasis, M., Cadena-Hinojosa, M., and Fry, W.E. 2004. Soilborne oospores of *Phytophthora infestans* in Central Mexico survive winter fallow and infect potato plants in the field. Plant Dis. 88:29-33

Forbes, G.A., Goodwin, S.B., Drenth, A., Oyarzun, P., Ordonez, M.E. and Fry, W.E. 1998. A global marker database for *Phytophthora infestans*. Plant Dis. 82 : 811-818.

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

Hirst, J. M., and Stedman, O. J. 1960. The epidemiology of *Phytophthora infestans*. II. The source of inoculum. Ann. Appl. Biol. 48:489-517.

Hu, C.-H., Perez, F. G., Donahoo, R., McLeod, A., Myers, K.., Ivors, K.., Secor, G., Roberts, P. D., Deahl, K. L., Fry, W. E., and Ristaino, J. B. 2012. Recent genotypes of *Phytophthora infestans* in eastern United States reveal clonal populations and reappearance of mefenoxam sensitivity. Plant Dis. 96:1323-1330.

Inglis, D. A., Powelson, M. L., and Dorrance, A. E. 1999. Effect of registered potato seed piece fungicides on tuber-borne *Phytophthora infestans*. Plant Dis. 83:229-234.

Johnson, D. A. 2010. Transmission of *Phytophthora infestans* from infected potato seed tubers to emerged shoots. Plant Dis. 94:18-23.

Kirk, W. W. 2003. Thermal properties of overwintered piles of cull potatoes. Am. J. Potato Res. 80: 145-149

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

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

Lambert, D. H. Currier, A. I., and Olanya, M. O. 1998. Transmission of *Phytophthora infestans* in cut potato seed. Am. J. Potato Res. 75:257-263.

Powelson, M. L., Ludy, R., Partipilo, H., Inglis, D. A., Gundersen, B., and Derie, M. Seed borne late blight of potato. Online. Plant Health Progress doi:10.1094/PHP-2002-0129-01-HM.

Zwankhuizen, M. J., Govers, F., and Zakoks, J. C. 1998. Development of potato late blight epidemics: Disease foci, disease gradients, and infection sources. Phytopathology. 88:754-763.

Funding: MPIC and Industry

Evaluation of fungicide programs for potato early blight and brown leaf spot control, 2012.

W. W. Kirk, R. Schafer, A. Merlington, S. Dangi and P. Somohan; Department of Plant, Soil and Microbial Sciences Michigan State University, East Lansing, MI 48824

Potatoes (cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 25 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All fungicides in this trial were applied on a 7-day interval from 5 Jul to 30 Aug (8 applications) with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal (80 psi) 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 N 6SC at 1.2 pt from early canopy closure on 5 Jul to 30 Aug. Weeds were controlled by hilling and with Dual 8E (2 pt on 3 Jun), Poast 1.5EC (1.5 pt on 13 Jul). Insects were controlled with Admire 2F (20 fl oz at planting), Sevin 80S (1.25 lb on 13 and 27 Jul), Thiodan 3EC (2.33 pt on18 Aug) and Pounce 3.2EC (8 oz on 13 Jul). Plots were rated visually for combined percentage foliar area affected by early blight and brown leaf spot on 14, 24 Aug and 4 and 12 Sep [19 days after final application (DAFA). Vines were killed with Reglone 2EC (1 pt on 6 Sep). Plots were harvested on 10 Oct and tubers from individual treatments were weighed and graded Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to desiccation (21 Sep). Average daily air temperature (^{o}F) from 1 May was 61.0, 67.0, 76.2, 68.0 and 59.7 and the number of days with maximum temperature >90^{o}F was 0, 3, 11, 2 and 0 (May, Jun, Jul, Aug, Sep, respectively). Average daily relative humidity (%) over the same period was 64.0, 61.3, 64, 68.9 and 66.1 (May, Jun, Jul, Aug, Sep, respectively). Average daily soil temperature at 4” depth (^{o}F) over the same period was 65.0, 73.1, 84.8, 72.3 and 64.9 and the number of days with maximum soil temperature >90^{o}F was 0, 5, 19, 0 and 0 (May, Jun, Jul, Aug, Sep, respectively). Average daily soil moisture at 4” depth (% of field capacity) over the same period was 34.8, 26.6, 32.1, 35.5 and 25.5 (May, Jun, Jul, Aug, Sep, respectively). Precipitation was 1.83, 1.78, 3.17, 3.82 and 1.07 in (May, Jun, Jul, Aug, Sep, respectively). 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 emergence on 10 Jun to 12 Sep (evaluation date) were 4009 P-days.

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 76.3% foliar infection by 12 Sep. All treatments had significantly less combined early blight and brown leaf spot than the untreated control except those with greater than 41.3% affected foliage. The RAUDPC estimated progress of Alternaria diseases over the course of the epidemic and treatments with RAUPDC values less than 19.8 were significantly different form the untreated control. Treatments with greater than US#1 yield of 283 cwt/A and total yield of 358 cwt/A were significantly different from the untreated control. Phytotoxicity was not noted in any of the treatments.

Funding: MPIC and Industry

Treatment and rate/A	EB/BLS (%)[a]		RAUDPC[b] 29 DAFE		Yield (cwt/A) US1		Total	
Aproach 2.08SC 9 fl oz + NIS 90SL 8 fl oz (A-H[c])………………..	41.3	bc[d]	14.0	bcd	326	abc	413	a-d
Aproach 2.08SC 12 fl oz + NIS 90SL 8 fl oz (A-H)……………….	36.3	c	14.9	bcd	322	a-d	400	a-d
Aproach 2.08SC 16 fl oz + NIS 90SL 8 fl oz (A-H)……………….	27.5	c	8.3	cd	328	abc	417	abc
Aproach 2.08SC 32 fl oz + NIS 90SL 8 fl oz (A-H)……………….	35.0	c	12.6	bcd	277	de	358	de
Vertisan 1.67EC 16 fl oz NIS 90SL 8 fl oz (ACEGI); Tanos 50WG 6 oz + Manzate 75WG 2 lb (BDFH)……………….	27.5	c	7.3	d	304	a-d	396	a-d
Tanos 50WG 6 oz + Manzate 75WG 2 lb (ACEGI); Vertisan 1.67EC 16 fl oz + NIS 90SL 8 fl oz (BDFH)……………	38.8	c	14.1	bcd	323	a-d	419	abc
Omega 500F 8 fl oz (A-H)…………………………………………	66.3	ab	24.8	ab	296	a-d	383	a-d
Echo ZN 4.17SC 34 fl oz (ACEI); Priaxor 4.17SC 4 fl oz + Echo ZN 4.17SC 32 fl oz (BDF); Dithane DF Rainshield 75DF 2 lb + Super Tin 80WP 2.5 oz (GH)..	35.0	c	20.0	abc	298	a-d	374	b-e
Echo ZN 4.17SC 34 fl oz (ACEI); Priaxor 4.17SC 4 fl oz + Echo ZN 4.17SC 32 fl oz (BF); Endura 70WG 3.5 oz + Echo ZN 4.17SC 32 fl oz (D); Dithane DF Rainshield 75DF 2 lb + Super Tin 80WP 2.5 oz (GH)..	18.5	c	7.2	d	338	a	430	ab
Echo ZN 4.17SC 32 fl oz (AEFGH); Reason 500SC 5.5 fl oz + Echo ZN 4.17SC 32 fl oz (B); Luna Tranquility 500SC 11.2 fl oz (CD)……………………..……	24.3	c	11.5	cd	337	a	436	a
Echo ZN 4.17SC 32 fl oz (ABEFGH); Luna Tranquility 500SC 8 fl oz (CD)…………………………...	36.8	c	15.5	bcd	332	ab	424	abc
Echo ZN 4.17SC 32 fl oz (ABEFGH); Luna Tranquility 500SC 11.2 fl oz (CD)…………………………..	20.5	c	7.0	d	289	bcd	382	a-d
Echo ZN 4.17SC 32 fl oz (ABEFGH); Quash 50WG 2.5 oz (CD)………………………………………….	40.0	bc	19.8	abc	300	a-d	398	a-d
EF400 100L 12 fl oz + ExCit 100L 4 fl oz (A-H)………………….	66.3	ab	28.1	a	283	cd	366	cde
Untreated Check………………………………………………….	76.3	a	30.4	a	236	e	319	e

[a] Combination of foliar infection due to a combination of early blight [EB (*Alternaria solani*)] *and* Brown leaf spot [BLS (*A. alternata*)] on 12 Sep, 29 days after appearance of initial symptoms of *Alternaria* spp.
[b] RAUDPC, relative area under the disease progress curve calculated from day of appearance of initial symptoms to 14 Sep (29 days).
[c] Application dates: A= 5 Jul; B= 12 Jul; C= 19 Jul; D= 25 Jul; E= 2 Aug; F= 9 Aug; G= 17 Aug; H= 24 Aug
[d] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD)

Funding: MPIC and MSU GREEEN

Identification of *Fusarium* Species Responsible for Potato Dry Rot in MI Commercial Potato Production (Progress Report).

Adam Merlington and W. Kirk
Department of Plant, Soil, and Microbial Science, Michigan State University, East Lansing, Michigan, USA.

Introduction

Potato dry rot is one of the most important postharvest diseases caused by several *Fusarium* species and is of worldwide importance (Secor and Salas, 2001). In the United States (US), yield losses attributed to dry rot in storage is estimated at $69 million to $228 million (unpublished data from United States Department of Agriculture, Schisler, D.). Currently there are at least 13 known *Fusarium* species responsible for potato dry rot in the US, while 11 of these species have been recently reported in the Northern US (Gachango et al. 2011). The most prevalent species reported by Hanson et al. (1996) were, *F. sambucinum, F. solani*, and *F. oxysporum.* In addition, Lacy and Hammerschmidt (1993) reported that of these species, *F. sambucinum* is the most predominant species affecting potato in storage and causing seed piece decay after planting and that *F. sambucinum* was the most aggressive of these species and contributes to major losses during storage. In a more recent survey conducted on Michigan potato seed stocks, the *Fusarium* species responsible for dry rot in seed tubers in Michigan (MI), a more diverse speciation emerged (Gachango et al., 2012). There has been no assessment of the composition of *Fusarium* species responsible for causing potato dry rot in MI commercial potato production and the objective of this study is to determine the structure and range of species responsible for dry rot in commercial potato crop production in MI.

Materials and methods

Dry rot symptomatic potato tubers (40-50) were collected in the fall of 2011 and 2012 from MI commercial potato production facilities. Nine cultivars were sampled from six different counties for a total of 13 fields and ten cultivars sampled from five different counties totaling 14 fields in 2011 and 2012, respectively. Small sections from the margins of necrotic or infected regions were cut with a scalpel, surface sterilized in 1.0% sodium hypochlorite for 10 s, rinsed twice in sterile distilled water, and blotted with sterile filter paper. The tissue pieces were plated on half-strength potato dextrose agar (PDA; Difco, Detroit, Michigan) amended with 0.5 g/L of streptomycin sulfate and incubated at 23°C for 5 to 7 d. Cultures resembling *Fusarium* species were transferred onto water agar (WA), and single hyphal tips from actively growing isolates were removed and plated on full strength PDA to generate pure cultures. *Fusarium* species were identified by extracting DNA from mycelium of pure cultures grown on PDA (described above). The translation elongation factor (EF-1α) gene region was amplified by polymerase chain reaction (PCR) and sequencing was performed using the high salt method adapted from the animal genomics laboratory (Aljanabi and Martinez 1997). The Fusarium-ID.v (Geiser et al., 2004) and the NCBI database were used to obtain the closest match topreviously sequenced identified isolates.

Fungicide sensitivity testing

Baseline fungicide resistance was determined by spiral gradient endpoint (SGE) analysis as described by Forster et al. (2004) and EC_{50} values were calculated using SGE software. The EC_{50} value was the concentration of fungicide that inhibited colony growth on PDA by 50%.

SGE analyses were conducted to determine EC_{50} values for thiabendazole (TBZ), fludioxonil, difenoconazole, and azoxystrobin. For all the fungicides, the stock concentration was 10000ppm. A spiral plater (Eddyjet II, IUL instruments, Barcelona, Spain) was used to apply 50 µL of each fungicide solution spirally using the exponential deposition mode, creating a fungicide gradient from a high concentration to a low concentration. Mycelial inoculum grown on PDA in 10-cm Petri dishes for 7 d was used to make conidial suspensions for each isolate. Conidial suspensions were prepared from cultures grown on PDA. The mycelia/conidia were scraped from the surface of aseptic pure cultures and the suspension filtered through a double layer of cheesecloth and adjusted to a concentration of 10^6 conidia/mL water. Conidial suspension for each isolate was streaked across the radial lines guided by an SGE template placed under the plate. Three replicates per isolate were used for each fungicide. In the SGE template and software, the 2 d incubation option was used for calculation of the local concentrations of fungicides where 50% growth inhibition was observed. Briefly, following incubation at 25°C for 2 d, the distance between the center of the plate at which mycelialgrowth was 50% of maximum observed growth (EC) and the point at which mycelia growth terminated were measured (TEC). The EC_{50} values were determined from the SGE software for each isolate by entering the EC and TEC values, respectively. Untreated controls consisted of spreading the conidial suspension on PDA plates without fungicide to compare fungal growth of no fungicides to the amended fungicide plates.

Pathogenicity testing

All isolates obtained through isolation were tested for pathogenicity on potato tubers cvs. Dark Red Norland and MSQ 440, which were known to be susceptible to dry, rot. Disease-free tubers were disinfected using 0.5% sodium hypochlorite and rinsed twice in sterile water. For each variety, three replicate tubers were wounded in the apical end using a cork borer to 0.5 mm depth and individual tubers were inoculated with each of the *Fusarium* isolates obtained. *Fusarium* cultures used for inoculation were grown on full strength PDA for 7 d. A cork borer was used to make the inoculating plug from the pure culture and one plug was transferred from the culture to the potato wound, using a sterile teasing needle. The potato plug was placed back into the original wound and sealed with petroleum jelly. Control tubers were inoculated with plugs of sterile water agar. The tubers were incubated in the dark for 30 d at 10^oC in controlled environment chambers. Tubers were cut longitudinally across the point of inoculation and evaluated for presence of symptoms or signs that were typical of potato dry rot. Isolates that caused typical symptoms or signs of dry rot on the tuber were considered pathogenic. The tuber lesions were scanned on a flatbed scanner (HP Scan-Jet 4c; Hewlett Packard Co.) and the images were analyzed using the measurement tools function in SigmaScan Pro 5 (Systat, Chicago, IL). The area of the lesion relative to the total area of the tuber surface was calculated. The relative area was expressed as a percentage and estimated the virulence of each isolate.

Results and Discussion

- A total of 518 *Fusarium* isolates to date, (Fig 1) were recovered from the infected tubers. *F. oxysporum* was the most common species recovered, comprising of 65.0% of the isolates. *F. equiseti*, *F. solani,* and *F. sambucinum* were less common (18.8, 8.0, and 5.8% of the population, respectively). Other isolates recovered included *F. avenaceum, F. acuminatum,,F. proliferatum,* and *F. sporotrichioides,* all found at low percentages of the population.

Funding: MPIC and MSU GREEEN

- All *Fusarium* isolates recovered were pathogenic on tubers of both varieties of potato tested.
- *F. sambucinum* was the most aggressive species based on percentage of the infected area.
- Isolates of the same species vary in levels of aggressiveness.
- All isolates of *F. sambucinum* were resistant to Thiabendazole (TBZ).
- Some isolates of *F. oxysporum* were resistant to difenoconazole, azoxystrobin, and fludioxonil (preliminary data and exact proportions of each are yet to be determined).

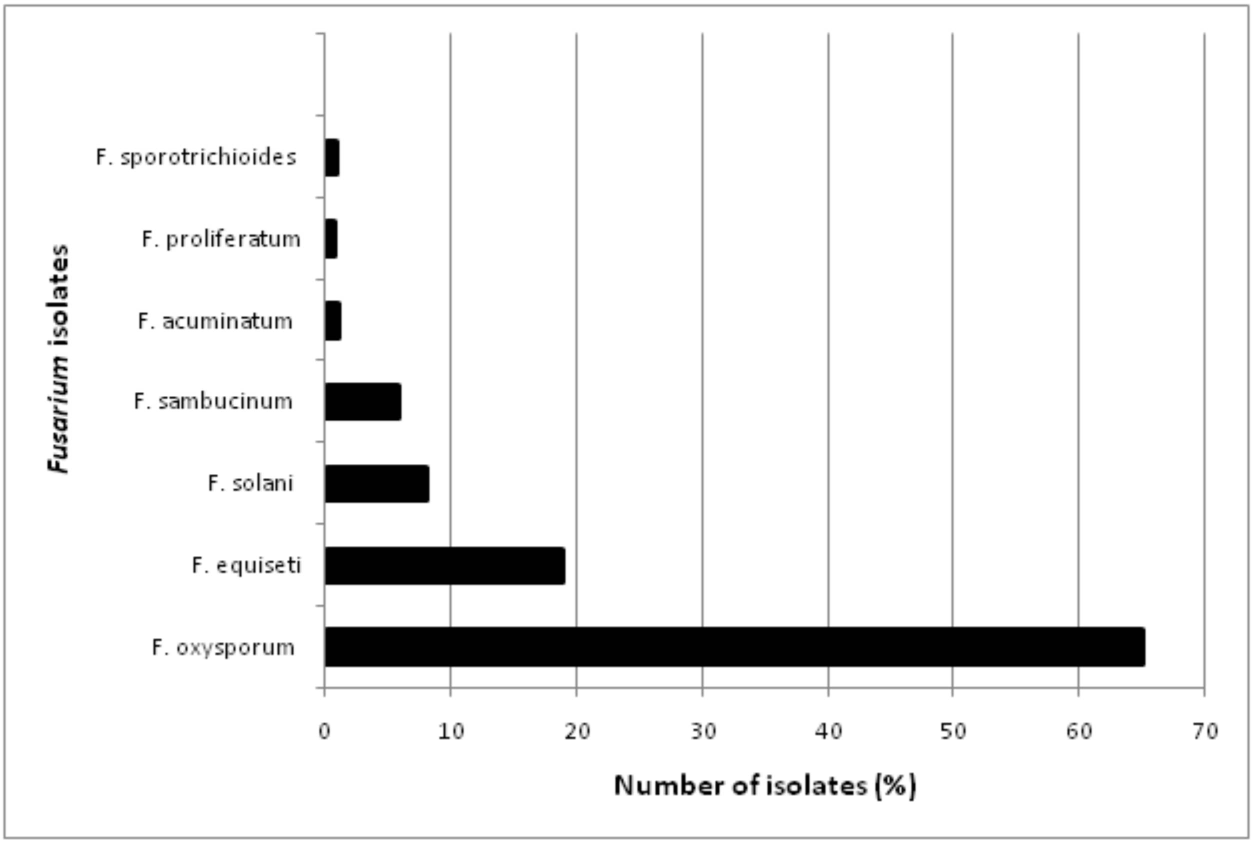


Figure 1: Species composition of *Fusarium* recovered from potato tubers in MI commercial potato production (2012).

Funding: MPIC and MSU GREEEN

References

Aljanabi, S. and Martinez I. (1997) Universal and rapid salt-extraction of high quality genomic DNA for PCR-based techniques. Nucleic Acids Research, 25: 4692–4693.

Animal Genomics Laboratory. (2001) School of Biological sciences. University of Liverpool.http://sciencepark.mdanderson.org/mbcore/protocols.html

Förster, H., Kanetis, L., and Adaskaveg, J. (2004) Spiral gradient dilution, a rapid method for determining growth responses and 50% effective concentration values in fungus-fungicide interactions. Phytopathology 94: 163-170.

Gachango, E., Kirk, W.W., Hanson, L.E., Rojas, A., and Hao, J.J. (2012) *Fusarium* spp. Causing Dry Rot of Seed Potato Tubers in Michigan and Their Sensitivity to Fungicides. Plant Disease, 95: 1767-1774.

Gachango, E., Kirk, W.W., Hanson, L.E., Rojas, A., Tumbalam, and P., Shetty, K. (2011) First report of *Fusarium torulosum* causing dry rot of seed potato tubers in Michigan. Plant Disease, 96: 1194.

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

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

Lacy, M. L. & Hammerschmidt, R. (1993) Fusarium dry rot. Retrieved Jan. 29, 2013, fromhttp://web1.msue.msu.edu/msue/iac/onlinepubs/pubs/E/E2448POT.PDF

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

Evaluation of fungicide programs for white mold (*Sclerotinia sclerotiorum*) and aerial stem rot (*Pectobacterium carotovora*) control in potatoes, 2012.

W. W. Kirk, and R. L. Schafer. Department of Plant, Soil and Microbial Science. MSU. East Lansing, MI 48824.

Potatoes ("Russet Norkotah", cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at the L. Yoder Farms, Sturgis, MI on 18 Apr (Bronson sandy loam); 42.4620, -85.22205 deg; elevation 880 ft. into four-row by 25-ft plots (ca. 10-in between plants at 34-in row spacing) replicated four times in a randomized complete block design with 2 rows (6-ft) between plots. The grower treated the trial area with Manzate 70DF (2 lb/A) applied at a 7-day interval. Fungicides for experimental control of white mold in this trial were applied on 17 Jul (95% canopy closure) and 31 Jul (100% inflorescence) with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal H_2O/A (80 p.s.i.) using three XR11003VS nozzles per row. One of the Omega treatments was applied in 5 gal H_2O/A to simulate aerial application. Plots were irrigated as needed with an overhead central pivot system and were hilled immediately before sprays began. Plots were hilled immediately before sprays began. Weeds were controlled by hilling and with Lorsban DF 1.5 lb + Dual 8E (1 pt/A on 9 May) and Select 2EC (8.0 fl oz/A on 11 Jul). Insects were controlled with Admire 2F (20 fl oz at planting on 18 Apr), Baythroid XL (1.0 fl oz/A on 20 Jun). Plots were rated visually for percentage foliar area affected by white mold and bacterial stem blight on 19 Jul and 2 Aug [2 and 16 days after final application (DAFA), 92 and 106 days after planting (DAP)]. Vines were killed with Reglone 2EC (1 pt/A on 6 Aug). Plots (1 x 25-ft row) were harvested on 24 Aug and individual treatments were weighed and graded. Meteorological variables were measured with a Campbell weather station located close to the farm, latitude 41.9833 and longitude -85.4333 deg, 840 ft. Meteorological variables were measured with a Campbell weather station located at the farm from 1 Apr to 31 Aug. Average daily air temperature (^{o}F) from 1 Apr was 49.3, 64.8, 69.5, 77.9 and 69.3 and the number of days with maximum temperature >90^{o}F was 0, 2, 7, 14 and 5 (Apr to Aug, respectively). Average daily relative humidity (%) over the same period was 61.7, 61.3, 60.9, 66.1 and 68.5 (Apr to Aug, respectively). Precipitation was 3.63, 1.68, 1.2, 1.75 and 1.11 in (Apr to Aug, respectively). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

White mold developed steadily during Aug and untreated controls reached 37.6 and 46.3% foliar infection by 19 Aug and 2 Sep, respectively. Fungicide programs with less than 28.8% and 42.5% white mold were significantly different to the untreated control up to 19 Jul and 2 Aug, respectively. Fungicide programs with greater than 26.3% and 48.8% bacterial stem rot were significantly different to the untreated control up to 19 Jul and 2 Aug, respectively. Programs with bacterial stem rot from 5.0 to 26.3% and 13.8 to 48.8% were not significantly different to the untreated control (12.5 and 30%) up to 19 Jul and 2 Aug, respectively. No fungicide programs had significantly different US-1 or total yield, respectively in comparison to the untreated control (336 and 458 cwt/A, respectively). Phytotoxicity was not noted in any of the treatments.

	White mold severity (%)		Bacterial vine rot severity (%)		Yield (cwt/A)	
	7/19	8/2	7/19	8/2		
Treatment and rate/acre	71 DAP[a]	85 DAP	71 DAP	85 DAP	US-1	Total
CX-10440* 100D 6.5 oz (A,B[b])………	28.8ab[c]	42.5ab	22.5bc	48.8ab	392a	495a
CX-10440 100D 13 oz (A,B)…………..	31.3ab	51.3a	42.5a	57.5a	287a	416a
Luna Tranquility 500SC 11.2 fl oz (A,B).	11.8cd	16.3c	26.3ab	45.0abc	332a	469a
Endura 70WG 5.5 oz wt/a (A,B)………..	8.8cd	15.0c	11.3bc	23.8cd	308a	458a
Omega 500F 5.5 fl oz (A,B)…………….	4.3d	10.0c	5.0c	17.5d	383a	497a
Omega 500F 5.5 fl oz (A,B[d])……………	8.0cd	17.5c	10.0bc	22.5cd	334a	453a
Rovral 4F 1 pt + NIS 100SL 4 fl oz (A,B)………………..	20.0bc	16.3c	13.8bc	17.5d	361a	483a
Rovral 4F 2 pt + NIS 100SL 4 fl oz (A,B)………………...	12.5cd	23.8bc	15.0bc	23.8cd	364a	462a
Tanos 50WG 8 oz (A,B)………………...	9.3cd	16.3c	10.0bc	18.8d	380a	494a
Untreated Check………………………...	37.5a	46.3a	12.5bc	30.0bcd	336a	458a

[a] DAP = Days after Planting.
[b] Application dates: A= 17 Jul; B= 31 Jul.
[c] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).
[d] Omega was applied in 5 gal H_2O/A to simulate aerial application.
* Experimental biological fungicide.

Funding: MPIC and Industry

Soil treatments for control of Verticillium wilt and Common Scab of potatoes, 2011-12.

A. Merlington[1], N. Rosenzweig[1], W. W. Kirk[1], R. L Schafer[1], C. Huthinson[2] and C. Furman[2]
[1]Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824; [2]Hendrix and Dale.

Soil treatments were applied at the Michigan State University Potato Research Farm, Clarksville, MI (Sandy loam soil complex Alfic Haplorthod; 1.8% OM; pH 6.2); 43.3526, -85.1761 deg; elevation 951 ft on 13 Oct 2011 by a tractor-mounted soil injection system calibrated to deliver 70, 98, 136 and 164 lb/A of the product PicPlus 85.5AP gal/A into prepared seedbeds 12 ft wide x 70 ft long. The seedbeds were replicated four times in a randomized complete block design. Potato seed ("FL1879") was prepared for planting by cutting two days prior to planting. Seed were planted on 8 May ca. 9-in between plants at 34-in row spacing to give a target population of 20,000 plants/A. Vydate was applied as a treatment on 8 May 2012 (at planting; 4.2 pt/A) and 12 Jun 2012 (at hilling; 2.1 pt/A). Fertilizer was drilled into plots before planting, formulated according to results of soil tests. Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 DAP (days after planting). Bravo WS 6SC 1.5 pt/A was applied on a seven-day interval, total of eight applications, for foliar disease control. Weeds were controlled by hilling and with Dual 8E at 2 pt/A 10 DAP, Basagran at 2 pt/A 20 and 40 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Plots (4 x 70-ft row) were harvested on 24 Oct and individual treatments were weighed and graded. Two plants per plot were harvested on 24 Aug [98 days after planting (DAP); 301 days after soil application of PicPlus (DASA) and 58 days after the final Vydate application] and the percentage of stems with signs or symptoms of Verticillium stem wilt on 9 Aug and tuber discoloration (vascular beading) was evaluated on 9 Aug and 24 Sep. Randomly selected samples of 100 tubers per plot were washed and assessed for common scab (*S. scabies*) incidence (%) and severity on 1 Nov 2012, 30 days after harvest (171 DAP). Severity of common scab was measured as an index calculated by counting the number of tubers (n = 100) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1=1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as an index from 0 – 100. The data were subdivided into the incidence and severity of common scab in each of the 6 classes and overall severity was estimated as Weighted Severity Index for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Oct. Average daily air temperatures (^{o}F) were 60.9, 69.5, 75.6, 68.2, 60.1 and 49.2 (May – Oct) with 1, 2, 15, 3, 0 and 0-d with maximum temperature >90^{o}F (May – Oct). Average daily soil moisture was 18.5, 14.9, 11.1, 13.1, 10.8 and 14.7 (% of field capacity at 2" depth; May – Oct) and 19.9, 14.3, 9.9,13.0,10.1 and 14.6 (% of field capacity at 4" depth; May – Oct). Average daily soil temperature was 60.4, 69.8, 76.5, 68.1, 61.7 and 50.9 at 2" depth (May – Oct) and 62.3, 72.1, 78.1, 68.9, 62.3, and 50.8 at 4" depth (May – Oct). Precipitation was 0.98, 0.99, 3.63, 3.31, 0.76 and 5.38 in. (May – Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4-d period with overhead pivot irrigation.

No treatment affected final plant stand or the rate of emergence (data not shown). No treatments affected Verticillium wilt in either the stems or the tubers measured as stem wilt or tuber discoloration in comparison to the untreated check both of which developed over the season to a significant degree throughout the trial. PicPlus applied at 136 lb/A had significantly less tubers in comparison the untreated check but no other treatments were significantly different. Common scab developed in the trial and all plots had about 60-70% incidence within Severity Group 6 (deep pitted scab), which on a quality scale would have made them difficult to market. PicPlus did not significantly reduce common scab incidence and severity in comparison to the untreated control and to the Vydate program. No soil applied products increased total yield in comparison to the untreated control although PicPlus 98 lb/A significantly increased total yield in comparison to the Vydate program. Soil treatments were not phytotoxic in terms of plant stand or rate of emergence.

Funding: MPIC and Industry

Table 1. Efficacy of PicPlus against Verticillium wilt and commons scab of potato, 2011-12.

Treatment and rate/A	Stem Number per plant[a]	Stems with Verticillium (%)[a]	Tuber number per plant 9 Aug (58 DAP)	Tubers with Verticillium (%)[a] (58 DAP)	Tuber number per plant 24 Sep (104 DAP)	Tubers with Verticillium (%)[a] (104 DAP)
Vydate 3.77SL 4.2 pt (B[b]),						
Vydate 3.77SL 2.1 pt (C)…...	6.9 a[c]	78.2 ab	9.8 abc	59.9 a	10.3 a	71.7 a
PicPlus 85.5AP 70 lb (A)…...	5.3 a	86.0 a	8.8 bc	66.7 a	8.5 a	66.3 a
PicPlus 85.5AP 98 lb (A)…...	6.1 a	69.3 b	10.1 abc	60.9 a	10.4 a	64.9 a
PicPlus 85.5AP 136 lb (A)….	5.1 a	82.6 ab	7.6 c	62.5 a	7.8 a	56.5 a
PicPlus 85.5AP 164 lb (A)….	5.5 a	74.9 ab	12.0 a	68.3 a	7.8 a	66.4 a
Untreated Check……………	6.1 a	83.1 ab	10.6 ab	47.4 a	8.1 a	57.1 a
$HSD_{0.05}$	2.08	16.43	2.86	27.25	3.76	23.27

Treatment and rate/A	Common scab incidence and severity index: Incidence SG6[d] (%)	Scab Index SG6[e] (0-100)	Scab Index Overall[f]	Total Yield (cwt/A)
Vydate 3.77SL 4.2 pt (B[b]),				
Vydate 3.77SL 2.1 pt (C)…...	72.0 a	58.5 a	21.2 a	333 b
PicPlus 85.5AP 70 lb (A)…...	71.5 a	58.5 a	21.0 ab	351 ab
PicPlus 85.5AP 98 lb (A)…...	66.5 a	49.6 a	18.9 b	410 a
PicPlus 85.5AP 136 lb (A)….	70.0 a	52.8 a	19.1 ab	388 ab
PicPlus 85.5AP 164 lb (A)….	76.5 a	59.7 a	20.4 ab	367 ab
Untreated Check……………	71.5 a	54.8 a	19.2 ab	375 ab
$HSD_{0.05}$	13.82	12.65	2.24	68.5

[a] Two plants per plot were harvested on 9 Aug [93 days after planting (DAP); 301 days after soil application (DASA)] and the percentage of stems and tubers with signs or symptoms of Verticillium stem wilt and tuber discoloration (vascular beading) were calculated.

[b] A = Soil treatments applied on 13 Oct, 2011 by a tractor-mounted soil injection system; B= in-furrow at planting application in 8 gal H_2O/A 8 May, 2012; C= hilling application in 8 gal H_2O/A 12 Jun, 2012.

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

[d] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 100) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1= 1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). These incidence data are for Scab Severity Group 6 only.

[e] Severity index data are for Scab Severity Group 6 only.

[f] Weighted Severity index data are for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100.

Funding: Industry and MPIC

Evaluation of fungicide programs for potato late blight control: 2012.

W. W. Kirk, R. Schafer, A. Merlington, S. Danghi and P. Somohan
Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824

Potatoes ('Snowden', cut seed, treated with Maxim FS at 0.16 fl oz/cwt) were planted at Michigan State University Horticultural Experimental Station, Clarksville, MI (Capac loam soil); 42.8733, -85.2604 deg; elevation 895 ft. on 15 May into two-row by 20-ft plots (ca. 10-in between plants to give a target population of 50 plants at 34-in row spacing) replicated four times in a randomized complete block design. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* [US-22 biotype (sensitive to mefenoxam, A2 mating type)] at 10^4 spores/fl oz on 31 Jul. 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 5 Jul to 24 Aug (8 applications) with an ATV rear-mounted R&D spray boom calibrated to deliver 25 gal/A (80 p.s.i.) using three XR11003VS nozzles per row. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 3 Jun), Poast (1.5 pt/A on 13 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting), Sevin 80S (1.25 lb/A on 13 and 27 Jul), Thiodan 3EC (2.33 pt/A on18 Aug) and Pounce 3.2EC (8 oz/A on 13 Jul). Plots were rated visually for percentage foliar area affected by late blight on 21, 28 Aug, 4 and 14 Sep [21, 28, 34 and 45 days after inoculation (DAI)] when there was about 75% foliar infection in the untreated plots. The relative area under the late blight disease progress curve was calculated for each treatment from the date of inoculation to 14 Sep, a period of 45 days. Vines were killed with Reglone 2EC (1 pt/A on 21 Sep). Plots (2 x 25-ft row) were harvested on 29 Oct and tubers from individual treatments were weighed and graded. A sample of 50 tubers was collected from each plot at harvest and stored at 50°F and 95% RH in the dark for 21 days. The incidence of late blight affected tubers was evaluated 21 days after harvest. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to desiccation (21 Sep). Average daily air temperature (°F) from 1 May was 61.0, 67.0, 76.2, 68.0 and 59.7 and the number of days with maximum temperature >90°F was 0, 3, 11, 2 and 0 (May, Jun, Jul, Aug, Sep, respectively). Average daily relative humidity (%) over the same period was 64.0, 61.3, 64, 68.9 and 66.1 (May, Jun, Jul, Aug, Sep, respectively). Average daily soil temperature at 4" depth (°F) over the same period was 65.0, 73.1, 84.8, 72.3 and 64.9 and the number of days with maximum soil temperature >90°F was 0, 5, 19, 0 and 0 (May, Jun, Jul, Aug, Sep, respectively). Average daily soil moisture at 4" depth (% of field capacity) over the same period was 34.8, 26.6, 32.1, 35.5 and 25.5 (May, Jun, Jul, Aug, Sep, respectively). Precipitation was 1.83, 1.78, 3.17, 3.82 and 1.07 in (May, Jun, Jul, Aug, Sep, respectively). Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation. The total number of late blight disease severity values (DSV) over the disease development period from 28 Jul to 14 Sep was 34 using 90%RH (ambient air) as a basis for DSV accumulation.

Late blight developed slowly but steadily after inoculation due to elevated air temperature during Aug and untreated controls reached on average 91.3% foliar infection by 14 Sep. Up to 30 Aug, all fungicide programs had significantly less foliar late blight than the untreated control. By 14 Sep, all programs had significantly better foliar late blight than the untreated control. All fungicide programs had significantly lower RAUDPC values in comparison to the untreated control (29.5). On 19 Nov (21 days after harvest) the percent incidence of infected tubers from untreated plots was 12.5%. Several treatments had significantly lower incidence of tuber blight in comparison to the untreated control and ranged from 3.0 to 7.0% in the most effective treatments. Treatments with greater than US1 yield of 176 cwt/A and total yield of 296 cwt/A, respectively were significantly different from the untreated control. Phytotoxicity was not noted in any of the treatments.

Funding: Industry and MPIC

Treatment and rate/A or rate per 1000 ft row	Foliar potato late blight 6 Sep 37 DAI[z]		14 Sep 45DAI		RAUDPC[y] 45 DAI		Tuber blight (%)[x] 7 Nov 187 DAP[w]		Yield (cwt/A) US1		Total	
Bravo WS 4.17SC 1.5 pt (A,C,E,G,H[v]); Zampro 4.38SC 11 fl oz + Hasten 16 fl oz (B,D,F)…………………..	10.3	bc[u]	33.8	bcd	6.1	bc	7.0	bc	164	ef	242	fgh
Bravo WS 4.17SC 1.5 pt (A,B,C,E,G); Zampro 4.38SC 11 fl oz + Hasten 16 fl oz (D,F,H)…………………..	4.0	cd	33.8	bcd	4.5	cde	7.5	abc	176	cde	240	gh
BravoWS 6SC 1.0 pt (A,C,E,G,H); Ranman 3.33SC 2.1 fl oz + Manzate 4F 43 fl oz + NIS[t] (B,D,F)...........	0.8	d	8.8	gh	1.1	f	6.0	bc	194	b-e	274	a-g
BravoWS 6SC 1.0 pt (A,C,E,G,H); Ranman 3.33SC 2.7 fl oz + Manzate 4F 43 fl oz + NIS (B,D,F)............	3.3	cd	12.5	gh	2.1	def	6.0	bc	226	a	306	a
BravoWS 6SC 1.0 pt (A,B,C,G,H); Ranman 3.33SC 2.7 fl oz + NIS (D,E,F).....	0.3	d	4.3	h	0.5	f	7.0	bc	190	b-e	268	a-g
BravoWS 6SC 1.0 pt + Ranman 3.33SC 2.1 fl oz (A,B,C,G,H); Gavel 75DF 2 lb (D); Ranman 3.33SC 2.73 fl oz + Manzate 4F 43 fl oz + NIS (E,F)……..…..	2.1	d	5.0	h	1.0	f	7.5	abc	201	a-d	283	a-d
BravoWS 6SC 1.0 pt + Ranman 3.33SC 2.1 fl oz (A,B); Gavel 75DF 2 lb (C); Ranman 3.33SC 2.73 fl oz + Manzate 4F 43 fl oz + NIS (D,E,F)…...…..	4.3	cd	8.8	gh	1.9	ef	6.0	bc	186	b-e	259	b-h
Gavel 75DF 2 lb + NIS (A-H)…………….	3.0	cd	10.0	gh	1.9	ef	3.0	c	175	cde	242	fgh
GWN-10126 4SC 32 fl oz (A-H)…………	4.3	cd	21.3	d-g	3.2	c-f	7.0	bc	196	a-d	296	ab
GWN-10127 75DF 24 oz (A-H)………….	1.5	d	5.3	h	0.9	f	9.0	ab	212	ab	289	abc
GWN-4700 80WP 3.4 oz + GWN-10043 90DF 17.8 oz + NIS (A-H)....	1.5	d	12.5	gh	1.8	ef	3.0	c	185	b-e	273	a-g
GWN-10043 90DF 20 oz + NIS (A-H)…...	1.9	d	7.0	h	1.1	f	5.5	bc	144	f	224	h
GWN-4700 80WP 3.4 oz (A-H)………….	3.4	cd	11.3	gh	2.0	def	5.0	bc	171	def	244	e-h
Manzate Prostick 75WG 1.5 lb (A-H)….....	1.5	d	17.5	e-h	2.3	def	7.0	bc	163	ef	245	e-h
Manzate Prostick 75WG 2 lb (A-H)……...	2.8	cd	21.3	d-g	3.3	c-f	3.0	c	172	def	250	d-h
Bravo WS 6SC 1.5 pt (A-H)……………...	2.8	cd	16.3	fgh	2.4	def	4.5	bc	184	b-e	263	b-g
KFD-107-01 75DF 1.5 lb (A-H)……….…	4.6	cd	27.5	c-f	4.2	cde	7.0	bc	190	b-e	259	b-h
KFD-107-01 75DF 2 lb (A-H)……………	3.9	cd	13.3	gh	2.3	def	5.5	bc	190	b-e	279	a-f
KFD-107-02 75DF 1.5 lb (A-H)……….…	6.8	cd	36.3	bc	5.5	bc	7.5	abc	171	def	249	d-h
KFD-107-02 75DF 2 lb (A-H)……………	6.4	cd	33.8	bcd	5.4	bc	8.5	ab	203	abc	281	a-e
Manzate Prostick 75WG 1.5 lb + KFD-104-01 2F 3 fl oz (A-H)…………….	15.1	b	42.5	b	8.0	b	8.5	ab	174	c-f	245	d-h
EC400 100L 16 fl oz + ExCit 100L 4 fl oz (A-H)………………….	6.3	cd	30.0	b-e	4.8	cd	4.5	bc	184	b-e	269	a-g
Untreated Check…………………………..	52.5	a	91.3	a	23.0	a	12.5	a	171	def	256	c-h

[z] Days after inoculation of *Phytophthora infestans* (US-22, A2 mating type, mefenoxam sensitive) on 31 Jul.
[y] RAUDPC, relative area under the disease progress curve calculated from day of appearance of initial symptoms to 14 Sep (45 days).
[x] Incidence of tuber late blight at harvest and after storage for 21 days at 50°F.
[w] Days after planting.
[v] Application dates: A= 5 Jul; B= 12 Jul; C= 19 Jul; D= 25 Jul; E= 2 Aug; F= 9 Aug; G= 17 Aug; H= 24 Aug.
[u] Values followed by the same letter are not significantly different at $p = 0.05$ (Fishers LSD).
[t] NIS = Non Ionic Surfactant applied at 0.25% v/v.

Funding: MPIC and MSU GREEEN

The Influence of Sulfur and Cultural Practices on Potato Common Scab Control

Adam Merlington, R. Shafer, N. Rosenzweig and W. Kirk.
Department of Plant, Soil, and Microbial Science, Michigan State University, East Lansing, Michigan, USA

Introduction

Potato common scab (PCS), caused by *Streptomyces* species, is a serious, recurrent, and important soil-borne disease of the potato (*Solanum tuberosum* L.) globally (Stevenson et al. 2001) particularly in Michigan (Wharton et al. 2007). Although PCS was first described in the literature more than 100 years ago, it continues to be a significant problem in potato production worldwide (Loria et al. 1997). Available information on losses due to PCS is limited, but economic losses of potatoes in Canada, due to PCS, are estimated to be between 15.3 and 17.3 million Canadian dollars in 2002 (Hill and Lazarovitz 2005). PCS affects the quality cosmetically of the tuber and ultimately the market value of the crop. Economic losses are greatest for tubers intended for table stock, although significant losses have been reported for chipping varieties. Common scab has a broad host range, being a disease on other root host crops, including, radish, turnip, beet, carrot, and sweet potato.

Potato scab lesions are variable. PCS is characterized by corky lesions on the tuber surface, which can be categorized into at least three symptomatic lesion types, including superficial, raised, or pitted (Figure 1). Scab lesions can be categorized further into discrete or coalescing. To further classify disease severity, an index of surface area infected using these categories was used. It is unclear as to what factors, strains or species determine the scab symptoms type or severity and are responsible for the lesion type and severity (Loria et al. 1997)

Incidence and severity of PCS vary based on location, from year to year, cultivar to cultivar, and from field to field. The variability and severity of the disease is of importance to MI and the US, where environmental conditions are favorable and often conducive for PCS (Stevenson et al. 2001). These conditions are typically warm, dry seasons, with high soil temperatures and variable rainfall (Stevenson et al. 2001). Reasons for the variability are not well understood, although many hypotheses have been described, including environmental factors and differences in cultivar susceptibility (Stevenson et al. 2001).

PCS is an efficient saprophyte that can overwinter in the soil, on tubers, and on crop residuals for over a decade. Most potato soils have a resident population of *Streptomyces* spp., which can increase with each succeeding host crop. The population can be reduced by rotation with other non-host crops but this practice does not eliminate the disease. Spores can persist in the soil for many years, and can germinate and infect in the presence of a suitable host. Infection of the potato tuber by *Streptomyces* occurs primarily through the lenticels and wounds (Wanner 2007). Therefore, tubers are most susceptible during the six-week period of tuber initiation and growth. Managers often implement their management strategies in the fall prior to the potato crop. Essentially, fall strategies focus on creating an environment unfavorable for *Streptomyces* and disease development.

Management of PCS is one of the most important challenges managers are facing in potato production worldwide. Different management techniques often provide inconsistent or inadequate results when relating to PCS incidence and severity. Scientists still struggle and have little understanding of the exact conditions or factors that contribute to the differences and variation of disease seen in the field. Cultural practices or management techniques are often implemented for control of PCS, but results are inconsistent, as with all management strategies. Acidic soils, with a level below 5.2 pH can also significantly reduce the incidence and severity of PCS (Stevenson et al. 2001). This management strategy can fail because *Streptomyces acidiscabies* can survive and cause PCS disease under these acidic conditions. Achieving a lower pH can be accomplished in many different ways. One successful approach has been the addition of sulfur to reduce the soil pH. Historically, sulfur has been used for PCS control, but the exact mechanism is not well known or understood. Researchers have found that the reduction in pH is not the only mechanism of control. Moreover, the addition of ammonium sulfate during tuber initiation can have a direct effect on PCS control possibly via volatile sulfur compounds (Pavlista, 2005).

Three trials were conducted which included:

1. To investigate the effects of applying elemental sulfur (ES) in the fall, prior to the potato field season, on pH, its influence on incidence and severity of PCS and to determine if different cultural or tillage techniques (chisel plow, and moldboard plow) influences incidence and severity of PCS;

2. To investigate the effects of different tillage techniques (minimal disturbance, chisel plow, and moldboard plow) influence the incidence and severity of PCS;

3. To investigate the effects of ammonium sulfate application in the spring, prior to tuber initiation and study the treatment effects on incidence and severity of PCS.

Methods Trial 1

The field trial was planted with the scab susceptible potato variety cultivar “Snowden” at the Michigan State University Potato Research Farm, Entrican, MI on 8 May 2012 into four-row by 50-ft plots (ca. 9-in between plants at 34-in row spacing) replicated four times in a split plot with randomized block design within the split. The split plot treatment was done in the fall, prior to the potato field season, and consisted of a moldboard plow to a depth of 12” depth along half the width of the plot and a chisel plow to a depth of 12” depth along the remainder, for a total split plot length of 200-ft. Moldboard plowing inverts the soil, while chisel plowing mixes the soil. Elemental sulfur (Tiger 90) at 400 lb/A was applied in the fall prior to the potato field season. Fertilizer was drilled into plots before planting, formulated according to soil tests results.

Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 DAP (days after planting) for a total of around 300 lb N/A. Weeds were controlled by hilling and Dual 8E at 2 pt/A 10 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire Pro 2F at 1.25 pt/A at plating, Seven 80S at 1.25 lb/A 31 and 55 DAP, and Pounce 3.2EC at 8oz/A 48 DAP. Potato late blight and general foliar diseases were prevented with weekly applications of Bravo WS at 1.5 pt/A starting at early canopy closure. Plots (4 x 50-ft rows) were harvested on 13 Sep 2012 following plant desiccation (123 DAP). Tubers were washed and assessed for PCS incidence and severity (see below) two weeks after harvest. Severity of PCS was measured as an index by rating 50 randomly selected tubers from each treatment and replication. The rating system classes were classified based on a 1-6 scale, falling into class based on lesion type: 1 = superficial discrete, 2 = coalescing superficial, 3 = raised discrete, 4 = raised coalescing, 5 = pitted discrete, and 6 = pitted coalescing (Figure 1). Tubers were further classified into (%) surface area covered with PCS tuber lesions using the Merz scale, with classes 0-6: 0= no scab, 1 = 0.1 - 2.0%, 2 = 2.1 – 5.0 %, 3 = 5.1 – 10 %, 4 = 10.1 – 25 %, 5 = 25.1 – 50.0 %, and 6 = > 50.0 %. The number of each lesion class was multiplied by the % surface area classes. The result is multiplied by a constant (21) to express the severity index as a percentage index from 1-100. These combined rating scales allow us to get qualitative and quantitative measures.

Results Trial 1

There were no significant differences between plowing treatments and elemental sulfur (ES) on overall scab incidence or severity and no significant effect on total yield (Table 1). PCS was severe in this trial and the incidence was in excess of 97%. However, upon analyzing the lesion classes individually, significant differences in PCS severity were identified for the group 6 (SG6) class (Table 1). Severity within the SG6 (deep pitted and coalescing) on a quality scale would make those tubers hard to market. ES had inconsistent results based on pH responses, but did reduce the pH on all but two replications (data not shown). The average pH of the site was 6.2 before ES application and averaged 6.1 following the application of ES. Toxic seed piece syndrome (TSPS) was identified in the trial, with greater severity in the chisel plow treatment. The moldboard treatment appeared to remain healthy for a longer period of time compared to the chisel treatment based on visual assessment.

Methods Trial 2

The field trial was planted with the scab susceptible potato cultivar "Snowden" at the Michigan State University Clarksville Research Station, Clarksville, MI on 17 May 2012 into four-row by 50-ft plots (ca. 9-in between plants at 34-in row spacing) replicated four times with complete randomized block design. The tillage treatments were done in the spring, prior to the potato field season, and consisted of a moldboard plow to a depth of 12" depth along the width of each replication, a chisel plow to a depth of 12" depth along the width of each replication, and a minimal disturbance that had no tillage technique implemented, for a total plot length of 200-ft.

Fertilizer was drilled into plots before planting, formulated according to soil tests results. Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 days after planting (DAP) for a total of 300 lb N/A. Weeds were controlled by hilling and Dual 8E at 2 pt/A 10 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire Pro 2F at 1.25 pt/A at plating, and two applications of Baythroid XL at 1.6 oz/A at 60 and 90 DAP. Potato late blight and general foliar diseases were prevented with weekly applications of Bravo WS at 1.5 pt/A starting at early canopy closure. Plots (4 x 50-ft rows) were harvested on 20 Sep, 2012 following plant desiccation (126 DAP). PCS was measured as described above.

Results Trial 2

There were no significant differences between plowing treatments on overall scab incidence and no significant effect on total yield (Table 2). PCS was severe in this trial and the overall incidence was 100%. There were significant differences found between plowing treatments on overall scab severity (Table 2). The moldboard plow treatment significantly reduced the overall scab index compared to the chisel plow and minimal-no till treatment. Upon analyzing the lesion classes individually, significant differences in PCS severity were identified for the severity group 6 (SG6; described above).

Methods Trial 3

The field trial was planted with the scab susceptible potato cultivar "Snowden" at the Michigan State University Clarksville Research Station, Clarksville, (described above). Fertilizer was drilled into plots before planting, formulated according to soil tests results. Treatments consisted of applying ammonium sulfate (AS) at 125 lb/A, 250 lb/A before tuber initiation on 21 Jun, 2012, 35 days after planting (DAP), and a control with no AS applications. Total nitrogen N was balanced throughout the treatments at the same time as the AS application by applying equal units of N using urea (46-0-0). Following the application of AS and N, the fertilizers were incorporated into the soil via 2 hours of overhead irrigation. Additional nitrogen was applied to the growing crop with irrigation 45 DAP for a total of 225 units of nitrogen. Weed, insects and diseases were controlled as described above. Plots (4 x 50-ft rows) were harvested on 20 Sep, 2012 following plant desiccation (126 DAP). Tubers were washed and assessed for PCS incidence (%) and severity 2 weeks after harvest. Incidence and severity of PCS were rated as described above.

Results Trial 3

There were no significant differences between ammonium sulfate (AS) treatments on overall scab incidence or severity compared to the control (Table 3). PCS was severe in this trial with an incidence of 100%. Furthermore, upon analyzing the lesion classes individually, no significant differences in PCS incidence or severity were identified for the SG6 (Table 3). Severity within the SG6 (deep pitted and coalescing) on a quality scale would make those tubers hard to market. ES had inconsistent results based on pH responses, but did reduce the pH on all treatments consisting of AS at 250lb/A and the treatment consisting of 125 lb/A had variable effects on pH (data not shown). The average pH of the site was 6.8 to 6.4 before AS application and was 6.2 to 6.8 following the AS application. Therefore AS had no significant effect on soil pH (data not shown).

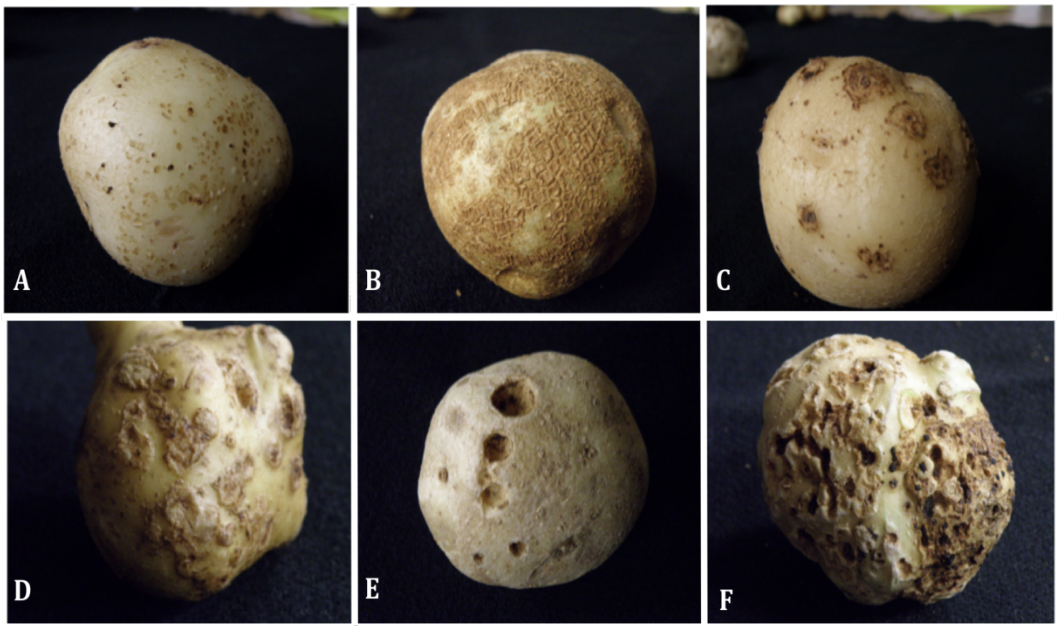


Figure 1. Schematic representation of the different severity levels of potato common scab (PCS) A: 1= superficial discrete; B: 2= coalescing superficial; C: 3= raised discrete; D: 4= raised coalescing; E: 5= pitted discrete; F: 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted)

Funding: MPIC and MSU GREEEN

Table 1. Effects of tillage type (moldboard and chisel plow) and elemental sulfur (Tiger 90) on incidence and severity of potato common scab.

	Common scab incidence and severity index			
Treatment	Incidence SG6[a] (%)	Scab Index SG6[b] (0-100)	Scab Index Overall[d]	Total Yield (cwt/A)
Moldboard….........................	51.8 a	38.3 a	17.3 a	259.9 a
Moldboard + Sulfur…............	45.5 ab	28.3 ab	15.8 a	215.9 a
Chisel…...............................	34.0 b	27.8 a	14.6 a	229.5 a
Chisel + Sulfur……………...	36.0 ab	23.8 b	14.4 a	289.3 a

[a] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1= 1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). These incidence data are for Scab Severity Group 6 only.

[b] Severity index data are for Scab Severity Group 6 only.

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

[d] Weighted Severity index data are for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100.

Funding: MPIC and MSU GREEEN

Table 2. Effects of tillage type (moldboard plow, chisel plow, and no till/minimal disturbance) on incidence and severity of potato common scab.

Treatment	Common scab incidence and severity index			
	Incidence SG6[a] (%)	Scab Index SG6[b] (0-100)	Scab Index Overall[d]	Total Yield (cwt/A)
Moldboard….....	56.0 b	39.6 b	10.9 b	186.7 a
Chisel………....	80.5 a	65.3 a	12.7 a	164.6 a
No till………....	82.0 a	64.6 a	12.6 a	173.2 a

[a] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1= 1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). These incidence data are for Scab Severity Group 6 only.

[b] Severity index data are for Scab Severity Group 6 only.

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

[d] Weighted Severity index data are for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100.

Funding: MPIC and MSU GREEEN

Table 3. Effects of ammonium sulfur (AS) on incidence and severity of potato common scab.

	Common scab incidence and severity index		
Treatment	Incidence SG6[a] (%)	Scab Index SG6[b] (0-100)	Scab Index Overall[d]
AS 250 lbs/A….....................	56.5 a	44.3 a	12.6 a
AS 125 1bs/A….....................	49.5 a	37.5 a	12.2 a
Control….............................	47.0 a	35.9 a	12.5 a

[a] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1= 1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). These incidence data are for Scab Severity Group 6 only.
[b] Severity index data are for Scab Severity Group 6 only.
[c] Values followed by the same letter are not significantly different at $p = 0.05$ (Honest Significant Difference; Tukey Multiple Comparison).
[d] Weighted Severity index data are for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100.

Literature Cited

Hill, J. and G. Lazarovits. (2005) A mail survey of growers to estimate potato common scab prevalence and economic loss in Canada. *Canadian Journal of Plant Pathology* 106:199-212.

Loria, R., Bukhalid R., Fry B., and R. King. (1997) Plant pathogenicity in the genus *Streptomcyes*. *Plant Disease* 81:836-846.

Pavlista, A. (2005) Early-season applications of sulfur fertilizer increase potato yield and reduce tuber effects. *Agronomy Journal* 97:599-603.

Stevenson, W., Loria, R., Franc, G., and D. Weingartner. (2001) Compendium of Potato Diseases. American Phytopathological Society, St. Paul, MN.

Wanner, L. (2007) A new strain of Streptomyces causing common scab in potato. *Plant Disease* 91:352-359.

Wharton, P., Driscoll, J., Douches, D., Hammerschmidt, R., and Kirk, W. 2007. Common Scab of Potato. In Extension bulletin. Michigan State University.

Funding: Industry and MPIC

Evaluation of crop protection programs for common scab control in potatoes, 2012.

A. Merlington[1], W. W. Kirk[1], N. Rosenzweig[1], R. Schafer[1]. [1]Department of Plant Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824

Potatoes (cut seed; "Snowden") were planted at the Michigan State University Potato Research Farm, Entrican, MI (sandy soil); 42.3526, -85.1761 deg; elevation 950 ft. on 24 May 2012 into two-row by 15-ft plots (ca. 9-in between plants at 34-in row spacing) replicated four times in a randomized complete block design. 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 and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire Pro 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Vines were killed with Reglone 2EC (1 pt/A on 15 Sep). Potato late blight and general foliar diseases were prevented with weekly applications of Bravo WS at 1.5 pt/A from early canopy closure on 29 Jun to 24 Aug. Plots (2 x 15-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Randomly selected samples of 50 tubers per plot were harvested 30 days after desiccation (approximately 140 DAP). Tubers were washed and assessed for common scab (*S. scabies*) incidence (%) and severity on 23 Oct, 30 days after harvest. Severity of common scab was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1=1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as an index from 0 – 100. The data were subdivided into the incidence and severity of common scab in each of the 6 classes and overall severity was estimated as Weighted Severity Index for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100. Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Oct. Average daily air temperatures (^{o}F) were 60.9, 69.5, 75.6, 68.2, 60.1 and 49.2 (May – Oct) with 1, 2, 15, 3, 0 and 0-d with maximum temperature >90^{o}F (May – Oct). Average daily soil moisture was 18.5, 14.9, 11.1, 13.1, 10.8 and 14.7 (% of field capacity at 2" depth; May – Oct) and 19.9, 14.3, 9.9,13.0,10.1 and 14.6 (% of field capacity at 4" depth; May – Oct). Average daily soil temperature was 60.4, 69.8, 76.5, 68.1, 61.7 and 50.9 at 2" depth (May – Oct) and 62.3, 72.1, 78.1, 68.9, 62.3, and 50.8 at 4" depth (May – Oct). Precipitation was 0.98, 0.99, 3.63, 3.31, 0.76 and 5.38 in. (May – Oct). Plots were irrigated to supplement precipitation to about 0.1 in./A/4-d period with overhead pivot irrigation.

Common scab was severe in the trial (98–100% overall incidence, data not shown). Only the incidence and severity index in common scab class 6 (coalescing pitted lesions) and overall severity index for scab classifications 0 through 6 were reported. Treatments with mean incidence of scab in severity class 6 ranged from 55.0 to 69.5%, and no treatments were significantly different from the untreated control. Treatments with mean severity of scab in severity class 6 ranged from 41.5 to 54.1 and no treatments had significantly lower indices in comparison to the untreated control. Treatments with mean severity of scab in the weighted overall scab index rating that was inclusive of all severity classes ranged from 15.5 to 18.1 and no treatments had significantly lower indices in comparison to the untreated control except Actinogrow 0.0371WP. Treatments with total yield from 158 (untreated) to 191, 166 to 196 and 191 to 216 cwt/A were not significantly different. No phytotoxicity was observed in this trial.

Funding: Industry and MPIC

Table 1. Efficacy of crop protection programs on incidence and severity of common scab and yield in potatoes.

Treatment rate/1000 ft row	Common scab incidence and severity index: Incidence SG6[a] (%)		Scab Index SG6[b] (0-100)		Scab Index Overall[c]		Total Yield (cwt/A)	
Serenade Soil 1.34SC 4.4 fl oz (A[d])..	63.5	abc[e]	45.8	a-d	16.1	abc	204	a
Serenade Soil 1.34SC 8.8 fl oz (A)…	55.0	c	42.3	cd	15.5	c	216	a
Blocker 4F 11 fl oz (A)…………….	58.0	bc	41.5	d	15.6	bc	196	ab
Serenade Soil 1.34SC 4.4 fl oz + Blocker 4F 5.5 fl oz (A)……………	58.0	bc	43.6	bcd	16.1	abc	203	a
Blocker 4F 11 fl oz + NAA 100F 0.017 fl oz (A)…………	65.5	ab	50.4	abc	17.1	abc	166	bc
Actinogrow 0.0371WP 1.67 oz (A)..	69.5	a	54.1	a	18.1	a	212	a
MBI-106020 20SC 8 fl oz (A)……..	67.5	ab	51.7	ab	17.7	ab	191	abc
MBI-106020 20SC 16 fl oz (A)…….	58.0	bc	44.2	bcd	16.4	abc	216	a
Untreated……………………………	60.0	abc	43.1	bcd	15.8	bc	158	c

[a] Severity of common scab was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0:0= 0%; 1:1 to 1:6; 2:1 to 2:6; 3.1 to 3:6; 4.1 to 4:6; 5.1 to 5:6; and 6.1 to 6:6 where the first number is the type of lesion (0= no lesions; 1= superficial discrete; 2= coalescing superficial; 3= raised discrete; 4= raised coalescing; 5= pitted discrete; 6=pitted coalescing surface area of tuber covered with tuber lesions (surface and pitted) and the second number is surface area affected (1= 1 lesion to 2%; 2= 2.1-5%; 3=5.1-10%; 4= 10.1-25%; 5=25.1%-50%; 6, > 50% surface area). These incidence data are for Scab Severity Group 6 only.

[b] Severity index data are for Scab Severity Group 6 only.

[c] Weighted Severity index data are for Scab Severity Groups 1 through 6; each severity index 1 through 6 was multiplied by 1, 2, 3, 4, 5 and 6, respectively then divided by a constant (21) to express the severity data as an index from 1–100.

[d] Application dates: A= 24 May.

[e] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: MPIC and Industry

Evaluation and comparison of fungicides for the control of post harvest potato tuber diseases (2011/13).

W. W. Kirk, R. Schafer, A. Merlington, N. Rosenzweig, P. Somohan, S. Dangi and L. Steere. Department of Plant, Soil and Microbial Sciences, Michigan State University, East Lansing, MI 48824.

Summary

Potatoes are susceptible to a variety of storage pathogens, including late blight (*Phytophthora infestans*), Pink rot (*Phytophthora erythroseptica*), (Fusarium dry rot (*Fusarium sambucinum*), Pythium leak (*Pythium ultimum*), black dot (*Colletotrichum coccodes*) 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.

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 $\pm$ 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 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 December 2011 with the potato cultivar “Monticello”. The tests were carried out at 10^{o}C (49^{o}F), chip processing. Potatoes free from visible diseases were selected for the trials from tubers harvested in October 2010. 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*, oospores/sporangia of *Pe*, oospores of *Py*, and macroconidia of *Fs* 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, (25/replicate/treatment; total 100 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 from 7 Nov 2011 to 27 Jan 2012 (77 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 severity was assessed using a disease severity index. Severity classes were determined as class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 – 20%; 4= 21 – 50%; 5 > 51 – 100% internal area of tuber tissue (dry rot) with disease and incidence is percentage of tubers in classes 1 - 5.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 8, Gylling Data Management) and mean separation calculated using Fisher's protected least significant difference (LSD) test at P= 0.05.

The trials conducted in 2012/13 followed the same methodology as described above except the variety x fungicide interaction trial utilized FL1833, FL1879, FL21317, Russet Norkotah and Superior and only late blight incidence was evaluated. Incidence was positive if tubers showed any signs or symptoms of the pathogen or the disease, respectively. The second trial was conducted as for 2011/12 except the variety was Snowden and only *Pi*, *Py*, and *Fs* were used. A18780A 441SC will be registered and marketed as Stadium by Syngenta Crop Protection.

Two further trials were conducted in 2012/13; 1) Effect of Stadium (A18780A) followed by CIPC on sprout number per tuber and the incidence of tubers with Fusarium and 2) Efficacy of Phostrol in mixture with Stadium against silver scurf.

Trial 1) Five varieties (Atlantic, Dark red Norland, FL21317, Russet Norkotah and Superior) were treated as described above on 26 Oct 2012 with A18780A 441SC at a rate of 0.05 fl oz/cwt in 3.2 fl oz H_2O/cwt. Samples were split and stored at two different locations at 4^{o}C in the dark for 117 days after the initial application (DAI) of A18780A. One sample was treated with CIPC 9.71L at a rate of 0.044 fl oz/cwt applied as a gas in an enclosed commercial storage. Tubers were not inoculated prior to either treatment. On 20 Feb 2013, 117 DAI tubers were rated for the number of sprouts that were greater than 0.5" long and the proportion of those that had symptoms of Fusarium sprout rot.

Trial 2) Dark Red Norland tubers with a background of about 100% incidence and 5% surface area affected by silver scurf (severity class = 1) were treated as described above on 28 Nov 2012 with A18780A 441SC at a rate of 0.05 fl oz/cwt in 3.2 fl oz H_2O/cwt in alone or in combination with Phostrol 53.6SC 1.28 fl oz/cwt. Tubers were not inoculated prior to treatment. On 27 Feb 2013, 91 DAIA tubers were rated incidence and severity of solver scurf using the Mertz scale described above.

Results and Conclusions

Efficacy of Phostrol plus Stadium against late blight, Pink rot, Pythium Leak and Fusarium dry rot; 2011/12 (Table 1)

In the late blight test at 10^{o}C, late blight developed in several treatments and the inoculated check had 78.0% incidence (Table 1). No late blight developed in the non-inoculated check. Treatments with less than 78.0% incidence of late blight were significantly different from the inoculated check. Treatments with greater than 8.0% incidence of late blight were significantly different from the non-inoculated check.

In the pink rot and Pythium tests, insufficient disease developed to permit analysis of data; about 2% in the pink rot study and 5% in the Pythium study and no disease developed in any of the treated plots.

In the black dot test, some black dot developed but there were significant difference among treatments. The incidence of tubers affected by black dot ranged from 13 to 20% and the severity index from 3.6 to 7.6 (Table 1).

In the dry rot trial, the three-way mixtures of fludioxinil, azoxystrobin and difenoconazole produced excellent control and at all rates of the fungicides and were significantly different from the inoculated check in terms of incidence and severity of dry rot.

Efficacy of Phostrol plus Stadium against late blight in different potato varieties, 2012/13 (Tables 2 and 3)

The analysis of variance of the main effects indicated significant effects of fungicide treatment and variety and interaction between the two variables on late blight incidence. All fungicide treatments significantly reduced late blight incidence in comparison to the untreated inoculated check. There was a significant effect of variety with Russet Norkotah being the least susceptible and FL2137 the most susceptible but there were no differences between FL1833, FL1879 and FL2137. The interaction between fungicide treatments and varieties indicated that all interactions were significantly different from the untreated controls within respective variety/fungicide treatment combinations. Treatments with less than 10.5% were not significantly different from the untreated non-inoculated checks. There were no significant differences between treatments with ranges of incidence from 4.9 to 19.8, 7.9 to 21.4, 9.5 to 24.3 and 15.1 to 27.7%. The addition of Stadium to Phostrol significantly improved the efficacy of Stadium but there was no effect on the efficacy of Phostrol applied alone against late blight.

Efficacy of Phostrol plus Stadium against late blight, Pythium Leak and Fusarium dry rot; 2012/13 (Table 4).

In the late blight test at 10^{o}C, late blight developed in several treatments and the inoculated check had 72.5% incidence. No late blight developed in the non-inoculated check. Treatments with less than 15.0% incidence of late blight were significantly different from the inoculated check. Treatments with greater than 15.0% incidence of late blight were significantly different from the non-inoculated check. Treatments with a severity index less than 4.3 were significantly different from the inoculated check. Treatments with a severity index greater than 55.0 of late blight were significantly different from the non-inoculated check.

In the Pythium test at 10^{o}C, Pythium Leak developed and the inoculated check had 76.0% incidence. No Pythium leak developed in the non-inoculated check. Treatments with less than 45.5% incidence of Pythium leak were significantly different from the inoculated check. No treatments were significantly different from the non-inoculated check. The severity index of Pythium leak in the untreated inoculated check was 38.8. All treatments had significantly lower severity of Pythium leak in comparison to the inoculated check. Treatments with greater than 3.5 severity indices were significantly different from the non-inoculated check.

In the Dry rot test at 10^{o}C, dry rot developed and the inoculated check had 60.0% incidence. No dry rot developed in the non-inoculated check. Treatments with less than 40.5% incidence of dry rot were significantly different from the inoculated check. Treatments with greater than 40.5% incidence were significantly different from the non-inoculated check. The severity index of dry rot in the untreated inoculated check was 38.7. All treatments had significantly lower severity of dry rot in comparison to the inoculated check. Treatments with greater than 7.6 severity indices were significantly different from the non-inoculated check.

The addition of Stadium to Phostrol significantly improved the efficacy of Stadium but there was no effect on the efficacy of Phostrol applied alone against late blight. The addition of Stadium to Phostrol did not significantly improve the efficacy of Stadium applied alone against Pythium leak. The addition of Stadium to Phostrol did not significantly affect the efficacy of Stadium applied alone against dry rot.

Efficacy of fungicides against late blight, Pythium Leak and Fusarium dry rot; 2012/13 (Table 5).

In the late blight test at 10^{o}C, late blight developed in several treatments and the inoculated check had 79.0% incidence. No late blight developed in the non-inoculated check. Treatments with less than 38.5% incidence of late blight were significantly different from the inoculated check. Treatments with greater than 29.5% incidence of late blight were significantly different from the non-inoculated check. Treatments with a severity index less than 38.5 were significantly different from the inoculated check. Treatments with a severity index greater than 12.4 of late blight were significantly different from the non-inoculated check.

In the Pythium test at 10^{o}C, Pythium Leak developed and the inoculated check had 76.0% incidence. No Pythium leak developed in the non-inoculated check. Treatments with less than 22.0 % incidence of Pythium leak were significantly different from the inoculated check. Treatments with greater than 19.5% incidence of Pythium leak were significantly different from the non-inoculated check. The severity index of Pythium leak in the untreated inoculated check was 18.0. All treatments had significantly lower severity of Pythium leak in comparison to the inoculated check. Treatments with greater than 8.3 severity indices were significantly different from the non-inoculated check.

In the Dry rot test at 10^{o}C, dry rot developed and the inoculated check had 76.5% incidence. No dry rot developed in the non-inoculated check. Treatments with less than 15.5% incidence of dry rot were significantly different from the inoculated check. Treatments with greater than 15.0% incidence were significantly different from the non-inoculated check. The severity index of dry rot in the untreated inoculated check was 44.1. All treatments had significantly lower severity of dry rot in comparison to the inoculated check. Treatments with greater than 7.0 severity indices were significantly different from the non-inoculated check.

Effect of Stadium (A18780A) followed by CIPC on sprout number per tuber and the incidence of tubers with Fusarium infected sprouts at 4^{o}C 110 and 117 days after fungicide and CIP treatment, respectively on a range of potato varieties; 2012/13 (Tables 6-7).

The main effects analyzed by 3-way ANOVA indicated that there were significant effects of variety; Stadium and CIPC in isolation and of the interactions among these variables on both sprout number and the incidence of Fusarium sprout rot. Superior had a significantly greater number of sprouts in comparison to other varieties but no other varieties were significantly different from each other regardless of fungicide or sprout suppressant. Treatment with Stadium over all varieties and regardless of CIPC treatment had significantly fewer sprouts per tuber than untreated tubers. Treatment with CIPC over all varieties and regardless of fungicide treatment had significantly fewer sprouts per tuber than untreated tubers. The interactions between varieties, fungicide treatment and CIPC treatment indicated that combinations with sprout numbers from 1.3 to 2.4, 2.4 to 3.6, 3.3 to 4.5, 4.4 to 5.3, 6.8 to 7.5 and 7.4 to 8.4 were not significantly different from each other.

Superior had a significantly greater number of sprouts affected by Fusarium in comparison to other varieties. FL2137 had a significantly lower number of sprouts affected by Fusarium in comparison to other varieties. No other varieties were significantly different from each other regardless of fungicide or sprout suppressant. Treatment with Stadium over all varieties and regardless of CIPC treatment had significantly lower number of sprouts affected by Fusarium per tuber than untreated tubers. Treatment with CIPC over all varieties and regardless of fungicide treatment had significantly lower number of sprouts affected by Fusarium per tuber than untreated tubers. The interactions between varieties, fungicide treatment and CIPC treatment indicated that combinations with number of sprouts affected by Fusarium per tuber from 0.0 to 1.9, 0.6 to 1.1, 0.9 to 9.0, 8.9 to 13.6, 11.7 to 17.6 and 17.6 to 25.9% were not significantly different from each other.

Efficacy of Phostrol in mixture with Stadium against silver scurf (Table 8).

In the silver scurf trial, silver scurf developed in all treatments and the inoculated check had 63.5% incidence. No treatments had significantly different incidence of silver scurf in comparison to the untreated check. Treatments with a severity index greater than 23.8 were not significantly different from the untreated check.

Funding: MPIC and Industry

Table 1. Severity and incidence of tubers with late blight, black dot and Fusarium dry rot Fusarium dry rot 90 days after treatment with fungicides at 10°C; 2011/12.

Treatments and rate of application per cwt of tubers	Fusarium Dry Rot Incidence (%)		Fusarium Dry Rot Severity Index[a]		Pythium leak Incidence (%)		Pythium leak Severity Index	
Phostrol 53.6SC 1.28 fl oz…	30.5	c[b]	17.5	c	2.0	e	2.0	de
Oxidate 27SC 0.125 fl oz……	28.5	cd	17.8	c	0.0	e	0.0	e
A12705P[c] 250SC 0.03 fl oz + A8574D 360FS 0.015 fl oz + A9859 230SC 0.03 fl oz……	6.5	ef	3.3	d	0.0	e	0.0	e
A18780A 441SC 0.05 fl oz	7.5	ef	3.0	d	2.5	e	1.8	de
A18780B 441SC 0.05 fl oz	12.0	e	4.6	d	2.5	e	2.1	de
BU POTS-1 100SC 0.2 fl oz..	21.5	d	13.6	c	7.5	d	4.9	cd
BU POTS-2 100SC 0.23 fl oz..	29.0	cd	19.0	c	9.0	cd	6.3	c
BU POTS-3 100SC 0.4 fl oz..	64.5	ab	38.5	b	13.0	bc	10.0	b
BU POTS-4 100SC 0.1 fl oz..	56.5	b	38.8	b	18.5	a	14.0	a
Non-inoculated check………	0.0	f	0.0	d	0.0	e	0.0	e
Inoculated check……………	68.0	a	47.9	a	15.0	ab	10.4	b

	Late blight Incidence (%)		Late blight Severity Index[a]		Pink rot Incidence (%)		Pink rot Severity Index	
Phostrol 53.6SC 1.28 fl oz…	0.0	g	0.0	f	0.0	g	0.0	g
Oxidate 27SC 0.125 fl oz……	10.5	ef	9.0	de	8.0	fg	7.9	f
A12705P[c] 250SC 0.03 fl oz + A8574D 360FS 0.015 fl oz + A9859 230SC 0.03 fl oz……	6.0	f	5.4	ef	8.5	f	8.3	f
A18780A 441SC 0.05 fl oz	7.5	ef	5.5	ef	6.0	fg	5.4	fg
A18780B 441SC 0.05 fl oz	7.5	ef	5.3	ef	8.0	fg	6.6	fg
BU POTS-1 100SC 0.2 fl oz..	21.5	bc	17.5	bc	29.5	d	27.4	d
BU POTS-2 100SC 0.23 fl oz..	16.5	cd	12.5	cd	38.0	c	35.6	c
BU POTS-3 100SC 0.4 fl oz..	13.0	de	10.1	de	69.0	a	65.6	a
BU POTS-4 100SC 0.1 fl oz..	36.5	a	31.1	a	58.5	b	56.4	b
Non-inoculated check………	0.0	g	0.0	f	0.0	g	0.0	g
Inoculated check……………	27.0	b	18.9	b	19.5	e	17.4	e

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 – 20%; 4= 21 – 50%; 5 > 51 – 100% internal area of tuber tissue (late blight and dry rot) with disease and incidence is percentage of tubers in class 1 - 5.
[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= fludioxonil.
[d] A18780 = mixture of azoxystrobin, difenoconazole and fludioxonil.

Funding: MPIC and Industry

Table 2. Main effects of treatment of a range of potato varieties with Stadium plus Phostrol on the incidence of tubers with late blight 90 days after treatment at 10^{o}C; 2012/13.

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	99	36584.23805				
Replicate	3	145.519075	48.506358	1.647	0.1881	3.07
Fungicide	4	31249.83762	7812.459404	225.323	0.0001	4.06
Error Fungicide	12	416.066387	34.672199	1.177	0.32	6.86
Variety	4	946.978973	236.744743	8.038	0.0001	3.43
Fungicide X Variety	16	2058.536768	128.658548	4.368	0.0001	7.68
Error B	60	1767.299235	29.454987			

Treatment	Late blight incidence (%)
Non-inoculated Check	0.0 d
Inoculated Check	52.9 a
Phostrol 53.6SC 1.28 fl oz	13.4 c
A18780A[a] 441SC 0.05 fl oz	20.7 b
A18780A 441SC 0.05 fl oz + Phostrol 53.6SC 1.28 fl oz	13.8 c
Variety	
FL1833	21.6 ab
FL1879	20.2 abc
FL2137	24.9 a
Russet Norkotah	15.7 c
Superior	18.4 bc

[a] A18780A = 3 way mixture of difenoconazole, azoxystrobin and fludioxonil

Funding: MPIC and Industry

Table 3. Severity and incidence of tubers with late blight, of a range of potato varieties with Stadium plus Phostrol on the incidence of tubers with late blight 90 days after treatment at 10°C; 2012/13.

Treatments and rate of application per cwt of tubers	Variety	Late blight Incidence (%)	
Non-inoculated Check	FL1833	0.0	f
	FL1879	0.0	f
	FL2137	0.0	f
	Russet Norkotah	0.0	f
	Superior	0.0	f
Inoculated Check	FL1833	45.6	a
	FL1879	49.3	a
	FL2137	55.3	a
	Russet Norkotah	54.1	a
	Superior	60.1	a
Phostrol 53.6SC 1.28 fl oz	FL1833	19.8	bcde
	FL1879	7.3	def
	FL2137	20.2	bcd
	Russet Norkotah	10.5	cdef
	Superior	9.5	cdef
A18780A[a] 441SC 0.05 fl oz	FL1833	24.3	bc
	FL1879	27.2	b
	FL2137	27.7	b
	Russet Norkotah	9.1	def
	Superior	15.1	bcde
A18780A 441SC 0.05 fl oz + Phostrol 53.6SC 1.28 fl oz	FL1833	18.1	bcde
	FL1879	17.2	bcde
	FL2137	21.4	bcd
	Russet Norkotah	4.9	ef
	Superior	7.3	def

[a] A18780A = 3 way mixture of difenoconazole, azoxystrobin and fludioxonil

Funding: MPIC and Industry

Table 4. Severity and incidence of tubers with Late Blight, Pythium Leak, Fusarium Dry Rot 91 days after treatment with fungicides at 10°C; 2012/13.

	Late Blight				Pythium Leak				Fusarium Dry Rot			
Treatments and rate of application per cwt of tubers	Incidence (%)		Severity Index[a]		Incidence (%)		Severity Index		Incidence (%)		Severity Index	
Non-inoculated Check ………	0.0	b	0.0	b	0.0	d	0.0	d	0.0	b	0.0	c
Inoculated Check……………	72.5	a	58.5	a	76.0	a	38.8	a	60.0	a	38.7	a
Phostrol 53.6SC 1.28 fl oz…..	15.0	b	4.3	b	45.5	b	23.6	b	40.5	a	21.6	b
A18780A[c] 441SC 0.05 fl oz…	76.3	a	55.0	a	11.5	c	7.2	c	16.0	b	7.6	bc
A18780A 441SC 0.05 fl oz + Phostrol 53.6SC 1.28 fl oz…...	8.8	b	2.5	b	8.5	cd	3.5	cd	12	b	6.2	c

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 – 20%; 4= 21 – 50%; 5 > 51 – 100% internal area of tuber tissue (late blight, Pythium and dry rot) with disease and incidence is percentage of tubers in classes 1 - 5.
[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] A18780 = mixture of azoxystrobin, difenoconazole and fludioxonil.

Table 5. Severity and incidence of tubers with Late Blight, Pythium Leak, Fusarium Dry Rot 90 days after treatment with fungicides at 10°C; 2012/13.

	Late Blight				Pythium Leak				Fusarium Dry Rot			
Treatments and rate of application per cwt of tubers	Incidence (%)		Severity Index[a]		Incidence (%)		Severity Index		Incidence (%)		Severity Index	
Non-inoculated Check ………	0.0	c	0.0	d[b]	0.0	c	0.0	c	0.0	c	0.0	c
Inoculated Check……………	79.0	a	45.2	a	33.0	a	18.0	a	76.5	a	44.1	a
A18659 79.84EC 0.09 fl oz A18660 48.8EC 0.147 fl oz A18661 206.4EC 0.027 fl oz	38.5	b	19.3	b	22.0	b	9.3	b	15.0	b	7.0	b
A19432A 398.93SC 0.05 fl oz	29.5	b	12.4	c	19.5	b	8.3	b	15.5	b	7.2	b

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 – 20%; 4= 21 – 50%; 5 > 51 – 100% internal area of tuber tissue (late blight, Pythium and dry rot) with disease and incidence is percentage of tubers in classes 1 - 5.
[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.

Funding: MPIC and Industry

Table 6. Main effects of treatment of a range of potato varieties treated with Stadium (A18780A) followed by CIPC on sprout number per tuber and the incidence of tubers with Fusarium infected sprouts at 4°C 110 and 117 days after fungicide and CIP treatment, respectively; 2012/13.

Source	N parm	DF	Sprout number/tuber Sum of Squares	F Ratio	Prob > F	Infected sprouts/tuber Sum of Squares	F Ratio	Prob > F
Variety	4	4	170.63	10.21	<0.0001	15904.71	18.09	<0.0001
Fungicide	1	1	181.89	43.57	<0.0001	119819.67	545.18	<0.0001
CIPC	1	1	6742.31	1615.20	<0.0001	4671.90	21.25	<0.0001
Variety* Fungicide	4	4	332.41	19.90	<0.0001	5777.81	6.57	<0.0001
Variety*CIPC	4	4	321.09	19.23	<0.0001	2383.80	2.71	0.0287
Fungicide*CIPC	1	1	179.57	43.01	<0.0001	658.13	2.99	0.0837
Variety*Fungicide* CIPC	4	4	210.41	12.60	<0.0001	5662.95	6.44	<0.0001

Variety			Fungicide treatment			CIPC treatment		
Sprout number/tuber								
Superior	5.9	a	Untreated	5.6	a	+	7.3	a
Russet Norkotah	5.3	b	A18780A	4.9	b	-	3.2	b
FL2137	5.2	b						
Dark Red Norland	5.0	b						
Atlantic	5.0	b						
Infected sprouts/tuber								
Superior	15.2	a	Untreated	18.6	a	+	11.6	a
Dark Red Norland	10.6	b	A18780A	1.3	b	-	8.2	b
Atlantic	9.3	b						
Russet Norkotah	9.2	b						
FL2137	5.4	c						

Funding: MPIC and Industry

Table 7. Sprout number and the incidence of tubers with Fusarium infected sprouts in a range of potato varieties stored at 4°C treated with Stadium (A18780A) followed by CIPC 110 and 117 days after fungicide and CIP treatment, respectively; 2012/13.

Variety	Fungicide	CIPC	Sprout number/tuber		Diseased sprouts/tuber (%)	
Atlantic	A18780A	+	3.3	de	0.6	ef
		-	7.1	b	0.0	f
	Untreated	+	2.4	ef	22.9	a
		-	7.0	b	13.6	bc
Dark Red Norland	A18780A	+	1.8	f	1.1	def
		-	6.9	b	0.0	f
	Untreated	+	3.7	d	22.4	a
		-	7.5	ab	17.6	ab
FL2137	A18780A	+	1.3	f	0.6	ef
		-	8.4	a	0.1	f
	Untreated	+	3.6	de	9.0	cd
		-	7.5	ab	11.7	bc
Russet Norkotah	A18780A	+	1.9	f	0.4	f
		-	6.8	b	0.0	f
	Untreated	+	5.3	c	24.0	a
		-	7.4	ab	12.3	bc
Superior	A18780A	+	4.4	cd	8.9	cde
		-	7.5	ab	0.9	def
	Untreated	+	4.5	cd	25.0	a
		-	7.1	b	25.9	a

Funding: MPIC and Industry

Table 8. Severity and incidence of tubers with Silver Scurf 90 days after treatment with fungicides at 10^{o}C; 2012/13.

Treatments and rate of application per cwt of tubers	Silver scurf Incidence (%)		Silver scurf Severity Index[a]	
Untreated Check ……..……	63.5	a[b]	38.7	a
Phostrol 53.6SC 1.28 fl oz…..	61.0	a	33.1	a
A18780A[c] 441SC 0.05 fl oz…	62.0	a	23.8	b
A18780A 441SC 0.05 fl oz + Phostrol 53.6SC 1.28 fl oz…...	63.0	a	20.6	b

[a] Severity classes were determined as class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 – 20%; 4= 21 – 50%; 5 > 51 – 100% external area of tuber surface with silver scurf lesions and incidence is percentage of tubers in classes 1 - 5.
[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] A18780A = 3 way mixture of difenoconazole, azoxystrobin and fludioxonil.

2012 Sectagon K-54 Research Report

George W. Bird
Michigan State University

In Michigan, the Potato Early-Die Disease Complex (PED) is caused by an interaction between the Penetrans root-lesion nematode (*Pratylenchus penetrans,* Nematoda) and the Dahliae Verticillium-wilt fungus (*Verticillium dahliae,* Mycota). This infectious disease has been recognized as a key limiting factor in Michigan potato production for about 40 years. PED is known to be a problem in about 50% of Michigan's potato acreage. Soil fumigation with 1,3-dichloropropene products was adopted in the 1970s by a limited number of farms for control of PED (1974-1978). By the late 1970s, soil fumigation was replaced throughout the entire industry with in-row, at-planting application of the nematicide/insecticide, aldicarb (Temik, 1975-1990). When regulations prohibited the use of aldicarb in Michigan potato production, it was replaced by metam (Vapam, Busan, Sectagon, 1985-present), oxamyl (Vydate, 1982-present) or ethoprop (Mocap, 1982-present).

In recent years, sodium-based metham products became the most widely used chemicals for PED control, enhancing tuber yields 30 to 150 cwt per acre, using the nematicidal rate of 37.5 gallons per acre (current formulation). Initially, metam was applied through the process of chemigation. This method of application was replaced with soil shank injection systems using metam diluted at a 4:1 water/metam ratio. Throughout the years, the dilution rate was reduced and today, some farms inject metam without diluting it with water. Some applicators inject metam at a 12-inch soil depth, while others use a split application system with outlets at 5-6 and 8-12-inch soil depths. In recent years, a significant number of Michigan potato growers have reduced their crop rotation systems to two-years, noticed a decline in the rate of corn stubble decomposition and believe that they periodically receive lower yield increases from application of metam than in the past. The potassium formulation of metam (Sectagon K54) has not been used by Michigan potato growers.

The first chemical control research related to PED at Michigan State University was conducted in 1973. Subsequently, a significant number of nematicides/fungicides have been evaluated for PED control. Between 1974 and 2012, more than 30 nematicide/fungicide PED research trials were conducted in Michigan. The mean tuber yield for the non-treated controls was 254 cwt per acre; whereas, the mean yield for metham (Sectagon, Vapam, Busan etc.) was 388 cwt per acre (Appendix A).

The objective of the 2012 Michigan Sectagon K-54 research project was to compare the efficacy and application rates of Sectagon K-54 and Sectagon 42 for control of PED on three commercial potato farm. The research was conducted at Sandyland Potato Farm, Walthers Potato Farms and Kitchen Potato Farm. Sandyland Farm was the only site where all three rates of both products were evaluated. This was a 23.7 acre research trial. The three sites were selected for their potential yield responses to metam application. Kurt Volker (TKI) visited the Sectagon Trials on August 21-22, 2012.

Farm No. 1 Trial

A 63.25 acre field (HO-31E) at a commercial potato farm in Michigan was selected for the 2011-2012 Sectagon research trial based on its risk to PED (Table 1). The 23.8 acre experimental design for the trial consisted of six soil fumigation treatments plus a non-treated control, each replicated four times in 0.85 acre strip plots (Table 2.) The chemical was shank-injected on November 1, 2011, to a soil depth of 12 inches without being diluted with water (Figures 1 & 2). Penetrans root-lesion nematode population densities were determined at application, at-planting, mid-season and at harvest. All twenty-eight plots were harvested on September 17, 2012 (Figure 3) and tuber yields determined after weighing the twenty-eight truckloads of tubers harvested (Figure 3). The mean tuber yield for the non-treated control was 383.7 cwt per acre (Table 2). All Sectagon treatments resulted in tuber yields significantly (P = <0.001) greater than the control. The highest tuber yield, 436.5 cwt per acre was associated with the Sectagon K54 treatment applied at at 60 gallons per acre. There were no statistically significant differences in tuber yields among the six Sectagon treatments (P = 0.290). At-planting in 2012, the population densities of P. penetrans associated with all treatments and the non-treated control were much lower than in the fall of 2011 (Table 4). The Sectagon treatmetns did not significantly lower the at-planting population densities of *V. dahliae.* Population densities of P. penetrans remained low throughout the 2012 growing Season (Table 5). No statistically significant (P = 0.651) differences in soil K were detected among the six Sectagon treatments and non-treated control (Table 6).

In summary, fall application of Sectagon resulted in significantly greater yields, compared to the non-treated control. The yield response, however, was less than expected. There was a general trend that higher rates of Sectagon resulted in slightly higher tuber yields. The research was unable to detect any reduction in population densities of *V. dahliae* associated with application of Sectagon at any of the three rate. The general population density crash associated with *P. penetrans* was detected independently by MSU Diagnostic Services and the G. W. Bird Nematology Laboratory.

Table 1. Pre-fumigation Penetrans root-lesion nematode, Verticillium-wilt fungus population densities and potato early-due risk assement data (Samples processed by MSU Diagnostic Services).

Pratylenchus per 100 cc soil	*Pratylenchus* per 1.0 g root tissue	*Verticillium* dilution planting per 1.0 g soil	*Verticillium* wet sieving per 10 g soil	PED Risk Index (0-5)
26	132	4	17	3

Table 2. 2011-1012 NovaSource Michigan Potato Fumigation Trial Plot Design.

Farm No. 1. (11/01/11, 1:30 - 4:00 p.m.) Fumigant Management Plan Addendum

Treatments and Replications

			I							II							III							IV					
4	3	2	1	6	5	7	2	5	3	4	7	1	6	5	7	3	6	1	2	4	2	3	5	1	4	6	7	6	7

Sample Number

			I							II							III							IV			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28

N

Pass Number

			I							II							III							IV					
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	35

Treatment

1. Non-Treated Control
2. Sectagon 42 38 gpa
3. Sectagon 42 50 gpa
4. Sectagon 42 75 gpa
5. Sectagon K54 30 gpa
6. Sectagon K54 45 gpa
7. Sectagon K54 60 gpa

Plot Size

1,300 x 28.5 ft (0.85 acres)

Experiment Size

23.8 acres

Figure 1.

Figure 2.

Figures 1 & 2. Farm No. 1. Soil fumigation equipment used in the research.

Table 3. Farm No. 1. 2012 Sectagon Research Tuber Yields Replilcates cwt/A

Treatment		I	II	III	IV	Mean
1. Non-Treated Control		388.6	374.1	389.8	382.3	383.7
2. Sectagon 42	38 gpa	425.5	427.9	430.8	416.8	425.25
3. Sectagon 42	50 gpa	425.3	422.6	432.8	429.6	427.575
4. Sectagon 42	75 gpa	424.4	439.5	425.3	426.6	428.95
5. Sectagon K54	30 gpa	434.1	424.8	431	426	428.975
6. Sectagon K54	45 gpa	428.1	434.7	435.8	418.7	429.325
7. Sectagon K54	60 gpa	455.5	438.4	438.4	413.6	436.475

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	4	1534.8	383.7	51.78
Row 2	4	1701	425.25	36.43
Row 3	4	1710.3	427.575	20.4425
Row 4	4	1715.8	428.95	50.28333
Row 5	4	1715.9	428.975	18.8825
Row 6	4	1717.3	429.325	61.73583
Row 7	4	1745.9	436.475	297.5425

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7452.348571	6	1242.058	16.18779	6.71E-07	2.572712
Within Groups	1611.29	21	76.7281			
Total	9063.638571	27				

Table 4. *Pratylenchus penetrans* per 100 cc soil on and *Verticillium dahliae* in Field H0 31E of Farm No. 1. on May 17, 2012 (samples processed by MSU Diagnostic Services).

Treatment	*Pratylenchus penetrans* per 100 cc soil	*Verticillium dahliae* per 10 g soil via wet-sieving
Non-treated Control	0	8.5
Sectagon 42 (38 gal/acre)	0	11.5
Sectagon 42 (50 gal/acre)	0	15.75
Sectagon 42 (75 gal/acre)	0	18.75
Sectagon K54 (30 gal/acre)	0.25	11.75
Sectagon K54 (45 gal/acre)	1.5	10.5
Sectagon K54 (60 gal/acre)	0	5.75
P	P = 0.0076	P = 0.290

Table 5. Mid-season and at-harvest population densities of *Pratylenchus penetrans* in Field H0 31E of Farm No. 1. (samples processed by in the G. W. Bird Nematology Laboratory).

Treatment	Mid-season *P. penetrans* per 1.0 g root	At-harvest *P. penetrans* per 100 cc soil
Non-treated Control	0	0.5
Sectagon 42 (38 gal/acre)	0	1
Sectagon 42 (50 gal/acre)	0.25	0
Sectagon 42 (75 gal/acre)	0.25	0
Sectagon K54 (30 gal/acre)	0	0.25
Sectagon K54 (45 gal/acre)	0	0
Sectagon K54 (60 gal/acre)	0.5	0.5
P	P = 0.636	P = 0.283

Figure 3. Farm No. 1. 2012 Sectagon Trial Harvest on September 17, 2012.

Table 6. Farm No. 1. Potato Trial

At-Harvest Soil Potassium (ppm)

Treatment	i	ii	iii	iv	mean
Non-Treated Control	143	160	163	128	148.5
Sectagon 42 38 gal	146	123	174	153	149
Sectagon 42 50 gal	120	182	234	110	161.5
Sectagon 42 75 gal	112	141	135	158	136.5
Sectagon K54 30 gal	165	137	146	173	155.25
Sectagon K54 45 gal	125	119	177	114	133.75
Sectagon K54 60 gal	147	160	165	196	167

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	4	594	148.5	264.3333
Row 2	4	596	149	442
Row 3	4	646	161.5	3350.333
Row 4	4	546	136.5	361.6667
Row 5	4	621	155.25	276.25
Row 6	4	535	133.75	851.5833
Row 7	4	668	167	431.3333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3592.214	6	598.7024	0.701115	0.651881	2.572712
Within Groups	17932.5	21	853.9286			
Total	21524.71	27				

Farm No. 2. Potato Farm Trial

A Cass County, Michigan potato field was used for the second 2011-2012 Sectagon reserch trial. The site was divided in to 750-foot long strips, each 62 feet wide (Table 6). It was selected as a typical field scheduled for 2011 fall fumigation with Sectagon 42 at a rate of 50 gallons per acre. The fumigant was diluted with 25% water and 60% of the resulting solution injected at a 5 inch soil depth and 40% at 10 inch soil depth on November 11, 2011. At-fumigation, both *P. penetrans* and *V. dahliae* were present, but the PED risk was low (Table 7). The mean at-plant population density of *P. penetrans* was significantly lower (P = 0.022) than when the site was fumigated. There was not corresponding decreased in the population density of *V. dahliae* (P = 0.737). The tuber hields were 533.3 and 568.5 cwt per acre for the Sectagon 42 and Sectagon K54 plots, respectively (Table 8). The Sectagon K54 treatment resulted in significantly greater (P = 0.052) higher yields compared to Sectagon 42. The mid-season and at-harvest population densities of *P. penetrans* were low and there were no statistically significantly differences between the Sectagon 42 and Sectagon K54 applications for the two dates, respectively (P = 0.835 and P = 0.330). Soil chemistry data for the trial are presented in Table 9. There were no statistically significant (P = 0.947) in soil potassium at-harvest between the Sectagon 42 and Sectagon K54. In summary, the way the products were applied, they functioned in a nematicidal and not a fungicidal mode.

Table 6. Farm No. 2. 2012 Soil Fumigation Trial Plot Design (Sectagon 42 (50 gpa), water (12.5 gpa), 60% at 5 inch soil depth and 40% at 10 inch soil depth. Sectagon K54 (60 gpa) 36 gpa at 5 inch soil depth and 24 gpa at 10 inch soil depth. Fumigated on Nov. 11, 2011.) The plot was harvested during the evening of Oct. 16, 2012, with seventeen truckloads of potatoes weighed.

woods

750 ft length pivot to woods	62 ft Sectagon 42	62 ft Sectagon K54	62 ft Sectagon 42	62 ft Sectagon K54	62 ft Sectagon 42	62 ft Sectagon K54	62 ft Sectagon 42	62 ft Sectagon K54	600 ft to field edge to pivot line

X Center Pivot

Table 7. Fall 2011 and spring 2012 population densities of *Pratylenchus penetrans* (Nematoda) and *Verticillium dahliae* (Mycota) associated with eight 750 foot-long strips at Farm No. 2. in Cass County, Michigan to be planted to potatoes in 2012.

Treatments	*P. penetrans* Nov. 11, 2011	*V. dahliae* Nov. 11, 2011	*P penetrans* April 3, 2012	*V. dahliae* April 3, 2012
Sectagon 42 50 gal/acre	18.5 per100 cc soil	7.8 cfu/10 g soil	6 per 100 cc soil	5.8 cfu/10 g soil
Sectagon K54 60 gal/acre	35.5 per 100 cc soil	6.3 cfu/10 g soil	0.5 /100 cc soil	6.8 cfu/10 g soil
P	P = 0.386	P = 0.697	P = 0.221	P = 0.743

Table 8. 2012 Farm No. 2. Sectagon Potato Yields (cwt/acre)

Treatment	Rate	Rep I	Rep II	Rep III	Rep IV	Mean (cwt/A)
Sectagon 42	50 gpa	494.3	555.2	561.1	522.6	533.3
Sectagon K54	60 gpa	588.6	582.1	570.1	533.1	568.475

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	2666.5	533.3	721.985
Row 2	5	2842.375	568.475	461.1719

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3093.202	1	3093.202	5.228726	0.051534367	5.317655
Within Groups	4732.628	8	591.5784			
Total	7825.829	9				

Table 9. 2012 Farm No. 2. Sectagon Trial Soil Chemistry.

Treatment	pH	CEC (%)	Ca (ppm)	K (ppm)	K (%CEC)	Mg (ppm)
1. Sectagon K54	7.4	18	992	528	18	146
2. Sectagon 42	6.8	10.9	1410	414	10.9	199
3. Sectagon K54	7	12.3	1245	424	12.3	182
4. Sectagon 42	6.2	3.5	1220	108	3.5	176
5. Sectagon K54	7.3	2.6	2444	146	2.6	238
6. Sectagon 42	7.8	8.7	2752	600	8.7	293
7. Sectagon K54	7.5	3	2345	176	3	324
8. Sectagon 42	7.5	3.2	2340	183	3.2	296

K (ppm)	I	ii	iii	iv	Mean
Sectagon K54	528	424	146	176	318.5
Sectagon 42	414	108	600	183	326.25

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	1592.5	318.5	26270.75
Row 2	5	1631.25	326.25	37698.19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	150.1563	1	150.1563	0.004695	0.9470552	5.317655
Within Groups	255875.8	8	31984.47			
Total	256025.9	9				

Farm No. 3 Trial

The Farm No. 3 site was planted to alfalfa in 2010 and 2011. Prior to fumigation, it had a moderate population density of *P. penetrans* (90 per 100 cc soil and 1.0 g root tissue). No *V. dahliae* was recovered from the soil using a wet sieving procedure.   A single field-long fumigation round was treated with Sectagon K54 on October 25, 2011 at a rate of 45 gallons per acre, with 50% of the product injected at a 6-inch soil depth and the other 50% at a soil depth of 12 inches. The remainer of the field was treated with Sectagon 42 at 50 gallons per acre.   At-planting on May 22, 2012, there were no Statistically significant differences in the *P. penetrans* or *V. dahliae* population densities between the two treatments. The *P. penetrans* population density, however, had been reduced to mean of 0.5 per 100 cc soil, and the *V. dahliae* population density was now detectable at the low level of a mean of 4.5 cfu per 10 g soil, indicating that at the rate used, Sectagon was functioning in a nematicidal and not a fungicidal mode. Tuber yields for the for the Sectagon 42 strip were 458.5 cwt per acre, compared to 447.5 ctw for the strip treated with Sectagon K54 (Table 11). Population densities of P. penetrans remained low throughout the growing season (Table 12).

Table 10. Farm No. 3. 2012 Sectagon Strip Trial Design

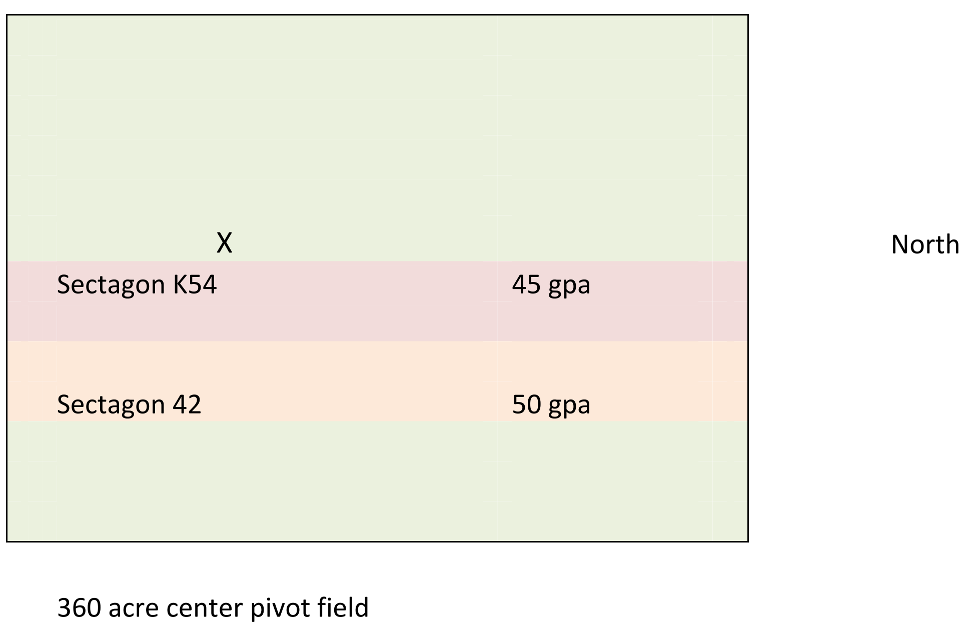


Table 11. Farm No. 3. 2012 Sectagon Trial Yield

Sectagon 42		
	East	476 cwt/A
	West	441 cwt/A
	Mean	458.5 cwt/A
Sectagon K54		
	East	449 cwt/A
	West	446 cwt/A
	Mean	447.5 cwt/A

t-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	458.5	447.5
Variance	612.5	4.5
Observations	2	2
Pearson Correlation	1	
Hypothesized Mean Difference	5	
df	1	
t Stat	0.375	
P(T<=t) one-tail	0.385799749	
t Critical one-tail	6.313751515	
P(T<=t) two-tail	0.771599498	
t Critical two-tail	12.70620474	

Table 12 Farm No. 3. Pratylenchus penetrans mid-season and at-harvest population densities associated with two Sectagon treatments.

Treatment	Mid-season per 100 cc soil	At-harvest per 100 cc soil
Sectagon 42 (45 gal/acre)	0	6
Sectagon K54 (50 gal/acre)	2	5

Appendix A. 1974-2012 Michigan Potato Early-Die Research Summary
Tuber Yield (cwt/A)

Year	Control	Metam	Temik	Vydate	Mocap	1,3-D
1974	388					467
1975	278		314			390
1976	176		209			180
1977	119		172			183
1978	267		371			365
1979	160		209			
1980	117		216			
1981	330		370			
1982	185		231	285	272	
1983	328		408			
1984	306		405			
1985	300	485	349			
1986	300	418	493			
1987	291	418				
1988						
1989	151		175	228		
1990	203		337			
1991	209			452		
1992	313	459				
1993	273			403		
1994	298	407		347	450	
1995						
1996	331		420	390	380	
1997	219		257		259	
1998	217	370		261	259	
1999	266	436	267			
2000	121	348				
2001	252	352				
2002						
2003						
2004						
2005						
2006	126	190		151		
2007						
2008						
2009	404	484		474		
2010						
2011	316	350				
2012	382	429				
Mean	254	388	306	324	324	317

2011-2012 DR. B. F. (BURT) CARGILL POTATO DEMONSTRATION STORAGE ANNUAL REPORT MICHIGAN POTATO INDUSTRY COMMISSION

Chris Long, Coordinator and Luke Steere

Introduction and Acknowledgements

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

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

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

This eleventh annual Demonstration Storage Report contains the results of the storage work conducted in the facility during the 2011-2012 storage season. Section I, "2011-2012 New Chip Processing Variety Box Bin Report", contains the results and highlights from our 10 cwt. box bin study. Section II, "2011-2012 Bulk Bin (500 cwt. bin) Report", shows bulk bin results including information from commercial processors regarding these new varieties.

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

We wish to acknowledge all the support and investment we receive to operate and conduct storage research. First, we express our gratitude for the partnership we enjoy between the MPIC and Michigan State University. Thank you to the MPIC Storage & Handling Committee

for their investment of time, guiding the decisions and direction of the facility. Steve, Norm and John Crooks, Crooks Farms, Inc.; Brian, Jeff and Alan Sackett, Sackett Potatoes; Jason Walther, Karl Ritchie and Keith Tinsey, Walther Farms; Tim, Todd and Chase Young, Sandyland Farms and Kyle Lennard and Fernando Montealegre, Lennard Ag Co.; these are the growers that provided the material to fill the bulk bins this year and without their willingness to be involved, we could not have accomplished our objectives. Equal in importance are the processors who invested in this research. They are Mitch Keeny of UTZ Quality Foods, Inc., Hanover, PA; and Al Lee and Phil Gusmano of Better Made Snack Foods, Detroit , MI. It has been a great pleasure to work with all of you. Special thanks to Butch Riley (Gun Valley Ag. & Industrial Services, Inc.) for his annual investment in the sprout treatment of the storage facility. We would also like to acknowledge a long list of additional contributors who invested much time to help foster a quality storage program: Dr. Dick Chase (MSU Professor Emeritus), Dr. Dave Douches and the MSU potato breeding program, Todd Forbush (Techmark, Inc), Larry Jensen (Chief Wabasis Potato Growers), and Tim Wilkes (Potato Services of Michigan). All played a role in making this facility useful to the Michigan potato industry.

Overview of the production season *

The overall 6-month average maximum temperature during the 2011 growing season was two degrees lower than the 6-month average maximum temperature for the 2010 season and was one degree lower than the 15-year average (Table 1). The 6-month average minimum temperature for 2011 was one degree higher than the 15-year average. There were 4 days with recorded temperature readings of 90 °F or above in 2011. There were 179 hours of 70 °F temperatures between the hours of 10 PM and 8 AM which occurred over 33 different days, April to September (Data not shown). There was one day in May that the minimum air temperature was below 32 °F. This occurred on May 5th. The average maximum temperature for July 2011, was four degrees higher than the 15-year average (Table 1). In October 2011, during the period from the 13th to the 31st there were only six days with no measureable rainfall. For the period from October 6th to October 9th, the recorded daytime high was 80 °F or higher four days in a row.

Rainfall for April through September was 14.92 inches, which was 3.5 inches below the 15-

year average (Table 2). In October 2011, 1.6 inches of rain was recorded. Irrigation at MRC was applied 8 times from June 30th to September 14th, averaging 0.74 inches for each application. The total amount of irrigation water applied during this time period was 5.95 inches.

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

I. 2011-2012 New Chip Processing Variety Box Bin Report

(Chris Long, Luke Steere and Brian Sackett)

Introduction

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

Procedure

Nineteen new varieties were evaluated and compared to the check variety Snowden. The 19 varieties were chosen by the MPIC Storage and Handling Committee. Once the varieties were chosen, 1 cwt. of each variety was planted on May 9th at the MSU, Montcalm Research Center, Entrican, MI. The varieties were all planted at a 10" in-row seed spacing. All varieties received a rate of fertilizer recommended to achieve a 375 to 425 cwt./A yield (270 lb. N/Acre). The varieties were vine killed after 120 days and allowed to set skins for 17 days before harvest on September 23, 2011; 137 days after planting. Variety maturity is not taken into account in the harvest timing due to storage and handling restrictions.

Approximately ten cwt. of each variety was placed in each box bin, labeled and stacked in bin 7. The average storage temperature for all the box bins (Bulk Bin 7) was 54.6 °F for the 2011-2012 season. At harvest, nine, 20 lb. samples from each variety were collected for weight loss and pressure bruise evaluation. A description of the varieties tested, their pedigree and scab ratings are listed in Table 1. Yield, size distribution, chip quality, and specific gravity were recorded at harvest (Table 2). All 20 varieties were graded to remove all "B" size tubers and pick-outs and entered the storage in good physical condition.

The storage season began September 23, 2011 and ended June 4, 2012. Bin 7 was gassed with CIPC on November 8, 2011. Variety evaluation began October 4th 2011 followed by a bi-weekly sampling schedule until June. Thirty tubers were removed from each box every two weeks and sent to Techmark, Inc. for sucrose, glucose, chip color and defect evaluation. Nine pressure bruise sample bags were taken for each variety, weighed and placed in one of the bulk bins at the storage facility. Three bags were placed at each of 5', 10' and 15' from the pile floor. When that bin was unloaded, the sample bags were weighed and percent weight loss was calculated. A 25 tuber sample was taken from each of the nine bags and was evaluated for the presence or absence of pressure bruise. The number of tubers and severity of bruise were recorded. All pressure bruises were evaluated for discoloration.

This report is not intended to be an archive of all the data that was generated for the box bin trial, but a summary of the data from the most promising lines. The purpose of this report is to present a summary of information from 2-5 lines from this trial that will be moved along the commercialization process. If more detailed information is desired, please contact Chris Long at Michigan State University in the Department of Plant, Soil and Microbial Sciences for assistance (517) 355-0271 ext. 1193.

Table 1. 2011 MPIC Demonstration Box Bin Variety Descriptions

Entry	Pedigree	2011 Scab Rating*	Characteristics
Lamoka (NY139)	NY120 X NY115	1.4	High yield, mid-late season maturity, medium specific gravity, oval to oblong tuber type, low internal defects
Snowden (W855)	B5141-6 X Wischip	2.4	High yield, late maturity, mid-season storage check variety, reconditions well in storage, medium to high specific gravity
A01143-3C	COA95070-8 X Chipeta	1.8**	Average yielding, scaly buff chipper; smaller tuber size, late maturity
AF2291-10	SA8211-6 X EB8109-1	1.8	Early blight resistant clone with good chipping quality, medium-late vine maturity, round to oblong, white netted tubers, specific gravity similar to Atlantic
CO00188-4W	A90490-1W X BC0894-2W	1.5	Below yield potential, small tuber size, minimal grade defects, medium-early maturity, high specific gravity, some ability to recondition out of 40 ºF
MSH228-6	MSC127-3 X OP	1.3	Average yield, mid-late season maturity, blocky flat tuber type, shallow eyes, medium specific gravity
MSL007-B	MSA105-1 X MSG227-2	1.1	Average yield, early to mid-season maturity, uniform tuber type, medium specific gravity, scab tolerant
MSQ070-1	MSK061-4 X Missaukee (MSJ461-1)	1.8	Round tuber type, late maturity, scab tolerance and late blight resistant, high specific gravity, strong vine and roots
MSQ089-1	A91790-13 X Missaukee (MSJ461-1)	2.1	Above average yield, uniform round tubers, medium maturity, good internal quality, average specific gravity
MSQ279-1	Boulder X Pike	1.0	High yield, large round tubers, good internal qualities, below average specific gravity
MSR036-5	MSL766-1 X Liberator	1.1	Below average yield, uniform round tuber type, medium maturity, average specific gravity

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. ** = 2010 Data

Entry	Pedigree	2011 Scab Rating*	Characteristics
MSR061-1	Mega Chip (W1201) X NY121	0.9	Below average yield, round tuber type with netted skin, low reducing sugars, PVY resistant, moderate late blight resistance
MSR157-1Y	Jacqueline Lee (MSG274-3) X MSJ316-A	2.6	High yielding, medium maturity, average specific gravity, yellow flesh
MSR159-2	MSL766-1 X MSJ126-9Y	1.7	Average yield, average specific gravity, medium-late maturity
MSR169-8Y	Pike X MSJ126-9Y	0.6	Below average yield, medium maturity, yellow flesh, average specific gravity, common scab resistant
MSS165-2Y	MSM188-1 X MSL159-AY	1.6	High yield, above average specific gravity, medium-late maturity, uniform round tuber type, heavy netted skin, yellow flesh, good internal tuber quality
NY140	NY121 x NY115	2.5	Late season, dual purpose chip and table stock. High yields of large tubers, lightly textured skin, resistant to race Ro1 of the golden nematode and moderately resistant to race Ro2.
NYE106-4	NY128 x Marcy	1.4	Late season, high gravity, scab-resistant chip stock
W2978-3	Monticello X Dakota Pearl	2.3	Above average yield potential, early bulking, medium-early vine maturity, scab susceptible
W4980-1	B0692-4 X W1355-1	2.0	Medium-early maturity for out-of-the-field chipping, moderate yield potential, low set

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. ** = 2010 Data

Table 2. 2011 Michigan Potato Industry Commission Box Bin Processing Potato Variety Trial

2011 MPIC Box Bin Processing Potato Variety Trial
Montcalm Research Farm, Montcalm County, MI

Harvest 23-Sep-11 137 Days

DD, Base 40[6] 3313

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	VINE	VINE		CHIP
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	VIGOR[4]	MATURITY[5]	COMMENTS	COMMENTS
MSS165-2Y	622	672	92	7	74	18	1	1.103	1.0	0	1	0	0	10	2.5	4.0	large yield, uniform round tubers	sl SED
NY140	527	588	90	10	86	4	0	1.094	1.0	0	6	0	0	10	3.0	3.5	oval to round tuber type, nice tuber appearance	moderate to severe SED
MSL007-B	514	542	94	6	87	7	0	1.098	1.0	0	0	0	0	10	2.0	3.0	nice uniform round type, heavy netted skin	moderate SED
NYE106-4	489	572	86	14	85	1	0	1.101	1.5	0	1	0	0	10	3.0	4.5		sl SED
MSQ089-1	463	518	89	10	89	0	1	1.080	1.0	0	3	0	1	10	3.0	2.5	tr black leg, uniform round size	sl SED
Lamoka	418	441	95	5	93	2	0	1.096	1.0	0	0	0	0	10	3.0	2.5		tr SED
W2978-3	355	410	87	12	87	0	1	1.083	1.5	0	2	0	0	10	3.5	1.0	flat round tubers	sl SED
AF2291-10	351	412	85	12	84	1	3	1.096	1.5	0	2	0	0	10	3.5	3.0	oval tuber shape	tr SED
MSQ070-1	349	456	77	23	77	0	0	1.096	1.0	0	1	0	0	10	3.0	4.5	sticky stolons	sl SED
MSR159-2	345	385	90	10	87	3	0	1.103	1.0	1	3	0	0	10	2.5	4.0	large tuber size	sl SED
MSQ279-1	345	380	91	6	82	9	3	1.077	1.5	0	0	0	0	10	3.5	4.5		moderate to severe SED
MSR157-1Y	326	371	87	12	86	1	1	1.088	1.5	1	2	0	0	10	2.5	2.0	flat round tubers	moderate SED, 10 white flesh tubers, mix
Snowden	**309**	**407**	**76**	**23**	**74**	**2**	**1**	**1.095**	**1.0**	**1**	**2**	**0**	**0**	**10**	**3.5**	**3.5**		**tr SED**
W4980-1	300	339	89	11	89	0	0	1.089	1.0	0	1	0	0	10	3.5	1.5	small round tubers	
MSH228-6	292	324	90	10	81	9	0	1.085	1.5	2	5	0	0	10	3.5	4.0		sl SED
MSR036-5	271	344	79	18	69	10	3	1.088	2.0	0	5	0	0	10	3.0	3.0	tr sticky stolon	
A01143-3C	260	437	59	20	59	0	21	1.093	1.0	0	2	0	0	10	3.5	4.5	heat sprouts in pickouts	tr SED
MSR061-1	181	265	68	31	68	0	1	1.094	1.5	0	2	0	0	10	2.5	2.0	uniform round tubers	sl SED
MSR169-8Y	141	197	72	25	72	0	3	1.091	1.0	0	1	0	0	10	2.0	3.5	light yellow flesh	
CO00188-4W	140	278	50	49	50	0	1	1.085	1.0	0	1	0	0	10	4.0	1.0	small round tubers	clean chips, small
MEAN	**350**	**417**	**82**					**1.092**										

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

SED = stem end defect, gc = growth crack

[1]SIZE	[2]TUBER QUALITY (number of tubers per total cut)	[3]CHIP COLOR SCORE - Snack Food Association	[4]VINE VIGOR RATING		[5]VINE MATURITY RATING		Planted:	9-May-11
Bs: < 1 7/8"	HH: Hollow Heart	(Out of the field)	Date Taken:	10-Jun-11	Date Taken:	24-Aug-11	Vines Killed:	6-Sep-11
As: 1 7/8" - 3.25"	VD: Vascular Discoloration	Ratings: 1 - 5	Ratings: 1 - 5		Ratings: 1 - 5		Days from Planting to Vine Kill:	120
OV: > 3.25"	IBS: Internal Brown Spot	1: Excellent	1: Slow Emergence		1: Early (vines completely dead)		Seed Spacing:	10"
PO: Pickouts	BC: Brown Center	5: Poor	5: Early Emergence (vigorous vine, some flowering)		5: Late (vigorous vine, some flowering)		No Fumigation	

[6]MAWN STATION: Entrican Planting to Vine Kill

<Back Contents Next> Print Quit

Results: 2011-2012 New Chip Processing Box Bin Highlights

MSL007-B

This Michigan State University (MSU) chip processing variety has common scab tolerance and a uniform round tuber type with a heavy netted skin. The specific gravity for this variety was 6 points above the trial average at 1.098. The recorded US#1 yield for this variety was above the trial average in the 2011 Box Bin Trial at 514 cwt./A (Table 2). The variety appears to have a medium-early to medium maturity with a good set of medium sized tubers (Table 1). The internal quality was excellent with no hollow heart or vascular discoloration reported at harvest in the raw tubers. Moderate stem end defect (SED) was reported in the out-of-the-field chip sample. The out-of-the-field chip color appeared to be good, scoring a 1.0 SFA score (Table 2). During the 2011-2012 storage season, MSL007-B was placed into storage on September 23rd, 2011 having a percent (X10) sucrose value of 0.755 and a glucose value of 0.002 percent. The sucrose values decreased quickly and remained low (0.501-0.402 percent) until the end of the storage season in late April. The percent glucose remained relatively high all season, ranging from 0.004 in late October 2011 to 0.012 in late April 2012. A chip picture is included from January 17th 2012 to show the chip quality during this period. The sucrose and glucose values on this day were 0.434 percent (X10) and 0.005 percent, respectively. A significant amount of SED was present in the chips on January 17th, 2012 as observed in the picture above. This defect was evident for a majority of the storage season. The percent weight loss recorded for this variety at the time of bin unloading was 4.49, with 12.0 percent of the tubers evaluated expressing bruise with discoloration under the surface of the skin. These numbers are higher than the majority of the varieties evaluated this season. Overall, this variety performed well agronomically, but the chip quality, this season, appears to be marginal. Further testing of this clone will continue in hopes of replacing Snowden acreage with a variety that has common scab resistance.

NYE106-4 (NY148)

This Cornell University developed variety exhibited an above average yield and specific gravity in the 2011 Box Bin Trial. The recorded yield for NYE106-4 was 489 cwt./A US#1 (Table 2). The specific gravity was the highest in the trial at 1.101. The tuber type and size was uniform with no pickout tubers recorded. This variety exhibits a stronger than normal vine vigor, resulting in what appears to be a late vine maturity. The out-of-the-field chip sample scored a 1.5 SFA score with a slight amount of stem end defect reported. On September 23rd, 2011, this variety was placed into storage with a percent sucrose (X10) of 0.886 and a percent glucose of 0.004. Sucrose and glucose levels came down to their lowest points in mid-January at 0.568 and 0.002, respectively. At this point in storage, the sucrose values began to rise to 1.200 percent in late May 2012. From mid-January 2012 until mid-April 2012, the glucose level remained at or below 0.003 percent. Total defects recorded for this variety in mid-April 2012 were 9.8 percent. The picture above captures NYE106-4 at its highest chip quality point from storage on January 17th, 2012. The percent weight loss recorded at the time of bin unloading for this variety was 1.47, with 14.7 percent of the tubers evaluated expressing bruise with discoloration under the surface. This variety has exhibited a very high level of susceptibility pressure bruising. This variety has excellent yield potential and moderate common scab tolerance, but chip quality appears to be questionable. Further storage and chip quality testing is required before this clone should be considered for commercialization.

Lamoka (NY139)

In the 2011 Box Bin Trial, Lamoka yielded above the trial average at 418 cwt./A US#1 with a specific gravity of 1.096 (Table 2). This Cornell University developed clone can have a slightly elongated and pear shaped tuber type in the larger oversized tubers, but has great yield potential, excellent chip quality and some moderate common scab tolerance. NY139 expresses better common scab tolerance and longer term chip quality than the check variety Snowden. The vine maturity for NY139 in this 2011 trial was medium. A nine to ten inch in-row seed spacing in central Michigan would be recommended for this variety because it can oversize. Out-of-the-field chip quality was excellent with only a trace of stem end defect reported. NY139 was placed into storage on September 23rd, 2011 with a 0.662 percent sucrose (X10) and a 0.002 percent glucose value. The sucrose and glucose levels were at their lowest in early February at 0.464 and 0.001, respectively. The picture above shows NY139 in early June 2012 with a 1.458 percent sucrose and a 0.003 glucose value. Even when the sucrose increased significantly, the glucose accumulated at a rather slow rate. This variety continues to exhibit excellent chip quality from storage late in the season. The tuber percent weight loss was reported at 2.48 percent, with 6.2 percent of the tubers having bruise and discoloration under the skin. NY139 appears to be as susceptible as other varieties to pressure bruise, but it appears to have a lower incidence of discolor than many varieties. Overall, this variety has great commercial potential. Its' yield and chip quality provide the industry with some potential improvements in duration of storability and common scab tolerance. Some questions have been raised regarding this varieties' potential susceptibility to storage rots. NY139's response to storage rot under commercial storage conditions will need to be tested in subsequent years.

Snowden

This variety is included as a reference point for the 2011 Box Bin Trial. The recorded yield for the Snowden variety was 309 cwt./A US#1 with a 1.095 specific gravity (Table 2). This variety yielded below the trial average in 2011. On September 23rd, 2011, this variety was put into storage with a 0.778 percent sucrose (X10) and a 0.002 percent glucose value. Sucrose and glucose levels came down to their lowest points in early February at 0.447 and 0.002, respectively. At this point in storage, the sucrose values began to rise to 1.232 in early April 2011. The percent glucose level was at 0.022 at this date. The chip picture above depicts Snowden during its last acceptable chip quality period in 2012. Total defects recorded for this variety on March 13th, 2012 were 13.3 percent with a percent sucrose (X10) of 0.658 and a percent glucose of 0.002. The percent weight loss recorded at the time of bin unloading for this variety was 3.88, with 0.0 percent of the tubers evaluated expressing bruise with discoloration under the surface.

II. 2011 - 2012 Bulk Bin (500 cwt. Bin) Report

(Chris Long and Luke Steere, Brian Sackett)

Introduction

The goal of the MPIC Storage and Handling Committee for the 2011-2012 bulk bin storage season was to develop storage profiles on four promising advanced clones and continue the evaluation of a three way tank mix of fungicides developed by Syngenta Crop Protection, Inc. This fungicide mixture is reported to control pathogen spread in potato storages. The pathology study was begun in the 2010-2011 storage season, was repeated in the 2011-2012 storage season and will be reported on in the 2012 MPIC Research Report. See the report by Dr. Willie Kirk et al. for the results of this storage pathology trial

The first variety tested for storage profiling was Lamoka (NY139), a clone from the potato breeding program at Cornell University, Ithaca, NY. This clone has a strong yield potential, specific gravity, great late-season chip quality and good common scab tolerance. The second variety, W2133-1 (Nicolet), developed at the University of Wisconsin, has good yield, good tuber qualities and good chip quality from mid-season storage. MSH228-6 and MSQ070-1, the third and fourth varieties of interest, are MSU developed clones. MSH228-6 is similar to Snowden in chip quality, but is more oval to oblong in tuber appearance, has common scab tolerance better than Snowden, but has a reduced set of tubers per hill. MSQ070-1 is round and uniform in tuber type with good agronomic quality, common scab and late blight tolerance and strong vigorous vines.

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

Procedure

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

In the 2011-2012 storage season; bins 1, 2 and 3 were filled with Lamoka (NY139); bin 4 was filled with W2133-1 (Nicolet); bin 5 with MSH228-6 and bin 6 with MSQ070-1. Bulk bins 8 and 9 were used for the pathology study and were filled with the variety Pike.

The Lamoka's were grown by Sackett Potatoes (bulk bin 1), Sandyland Farms, (bulk bin 2) and Lennard Ag. Co., (bulk bin 3). Bin 1 was filled on October 4th, 2011. The seed was planted May 21st, 2011, and vine killed on September 9th, 2011 (112 DAP, 3173 GDD_{40}). The variety was harvested October 3rd, 2011; 136 days after planting. The pulp temperature for the bulk bin 1 Lamoka's at the time of bin loading was 59.0 °F. Minor tuber skinning was observed at the time of bin loading. Bin 2 was filled on October 11th, 2011. The seed was planted June 1st, 2011, and vine killed on September 15th, 2011 (107 DAP, 3050 GDD_{40}). The variety was harvested October 10th, 2011; 132 days after planting. The pulp temperature for the bulk bin 2 Lamoka's at the time of bin loading was 65.0 °F. Significant tuber skinning was observed at the time of bin loading. Bin 3 was filled on November 10th, 2011. They were planted May 11th, 2011, and vine killed on September 17th, 2011 (130 DAP, 3877 GDD_{40}). The variety was harvested November 7th, 2011; 181 days after planting. The pulp temperature for the bulk bin 3 Lamoka's at the time of bin loading was 43.9 °F. A large amount of mechanical tuber damage was noted at the time of bin loading. A blackspot bruise sample was taken on each bin at the time of bin loading. The results indicated that the tubers in bin 1 were 88% bruise free, the tubers in bin 2 were 85% bruise free and the tubers in bin 3 were 40% bruise free.

The W2133-1 (Nicolet, bulk bin 4) was grown by Walther Farms, St. Joseph County, MI. Bulk bin 4 was filled on October 13th, 2011. The seed was planted May 9th, 2011, and vine killed on September 10th, 2011 (125 DAP, 3812 GDD_{40}). The variety was harvested October 13th, 2011; 158 days after planting. The pulp temperature at the time of bin loading was 64.0 °F. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers in bin 4 were 90% bruise free.

The MSH228-6 (bulk bin 5) was grown by Lennard Ag. Co. Bin 5 was filled on November 10th, 2011. The seed was planted June 3rd, 2011, and vine killed on September 17th, 2011 (107 DAP, 3315 GDD_{40}). The variety was harvested November 7th, 2011; 158 days after planting. The pulp temperature at the time of bin loading was 48.0 °F. A large amount of mechanical tuber damage was noted at bin filling. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers in bin 5 were 48% bruise free.

The MSQ070-1 (bulk bin 6) was grown by Walther Farms, St. Joseph County, MI. Bin 6 was filled on October 24th, 2011. The seed was planted May 3rd, 2011, and vine killed on September 22nd, 2011 (143 DAP, 4122 GDD_{40}). The variety was harvested October 23rd, 2011; 174 days after planting. The pulp temperature at the time of bin loading was 54.5 °F. A blackspot bruise sample was taken on this variety at the time of bin loading. The results indicated that the tubers in bin 6 were 93% bruise free.

Bins 1, 2, 4 and 6 were gassed with CIPC on November 8th, 2011. Bins 3, 5 and 6 were gassed with CIPC December 2nd, 2011. On January 25th, 2011, bins 1, 2, 3 and 4 were gassed for a second time with CIPC. Bin monitoring began the day the tubers were placed into storage and were evaluated on a two week sampling schedule thereafter. Forty tubers were removed from the sample door in each bin every two weeks and sent to Techmark, Inc. for sucrose, glucose, chip color and defect evaluation. The sample door is located in the center back side of each storage bin and is an access door that allows samples to be taken from the pile three feet above the bottom of the pile. Pressure bruise evaluation began by collecting nine, 20 to 25 lb. tuber samples as each bin was being filled. Three samples were placed at each of three different levels within the bulk bin pile at 5, 10, and 15 feet from the storage floor.

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

Objective

The Storage and Handling Committee's objective in testing the varieties in bins 1-6 was to determine what the optimal storage temperature was for each variety, while maintaining acceptable storage and chip quality. Also of interest was the level of pressure bruise damage that may be incurred by each variety at a given storage temperature. The goal for the Lamoka (NY139) variety was to evaluate longevity at a given storage temperature while maintaining chip quality. Based on initial storage sugar samples from bins 1 and 2, a long-term storage profile was established. The bulk bins were suberized and then cooled, as chip quality allowed, to 48.0 °F. The Lamoka's in bulk bin 3 exhibited physical and chemical signs of tuber stress at bin loading. Due to the cold pulp temperature at bin loading, the tubers were warmed to 55.0 °F to suberize. The tubers were slated for short-term storage, hoping that the chip quality could be improved with good air flow and a warmer pile temperature to enhance tuber respiration. Tubers were maintained at 54.0 °F. Bulk bin 4 (W2133-1) was suberized and then cooled to 54 °F. The goal for this variety was a mid-season storage profile. The MSH228-6 in bulk bin 5 was physically and chemically out of condition at the time of bin loading. The tuber pulp temperature was warmed to 55.0 °F to encourage suberization and then the tubers were held at this same temperature with good fresh air volume to increase respiration of free sugars. The goal for these potatoes at this time was to improve chip quality and then ship for processing. The chip quality of bin 6 was not acceptable, as indicated by high sucrose and glucose values at harvest. The pile temperature was maintained at 55.0 °F to encourage respiration of sugars and a shipping plan will be established as chip quality is evaluated.

Bulk Bin 1, Lamoka (NY139)

Lamoka is a common scab tolerant, round to oval shaped chip processing variety from Cornell University. The variety produces good chip quality from 48 °F long-term storage. In the 2011 on-farm variety trials, this line yielded 433 cwt./A US#1. It has a four year yield average from 2008-2011 of 417 cwt./A US#1. The specific gravity of this variety averages between 1.078 – 1.085. Potential draw backs of this variety could be Black Leg, Pythium Leak, Pink Rot and Black Heart susceptibility. These defects need to be evaluated more extensively over different environments and years.

Figure 1. Techmark-Inc. chip picture, bin 1 Lamoka, 3.7.12

For the 2011-2012 storage season, this variety was grown by Sackett Potatoes, Mecosta, Michigan, which is located in Mecosta County. The tuber pulp temperature upon arrival at the storage was 59.0 °F. The variety was tested and found to be 88 percent black spot bruise free after bin loading. The tuber quality was generally good with some slight skin feathering present. This bin was held for a period of suberization and then cooled slowly. Sugar levels were monitored as the pile was cooled to a target storage temperature of 48.0 °F.

This bin was loaded on October 4th and was held at 56.0 °F for wound healing until early November, at which time the sucrose levels decreased to 0.662 percent (X10). There were no sugar related chip defects recorded all season for the Lamoka's in this bulk bin. The sucrose and glucose levels were at their lowest point in early March, just prior to processing at a value of 0.452 percent (X10) and 0.001 percent, respectively. See the Techmark Inc. March 7th generated photo in the upper right corner which correlates to these sugar numbers (Figure 1). Bin 1 was chip processed in mid-March for a chip processing test conducted by the United States Potato Board. The ending pulp temperature was 48.0 °F when shipped on March 7th, 2012 to Better Made Inc., Detroit, MI. At the time of bin unloading, tuber weight loss was 4.35 percent, with 0.9 percent of the tubers that expressed pressure bruise having discoloration under the skin. This variety appears to pressure bruise similarly to other varieties, but the discoloration under the pressure bruise area was observed at a very low incidence level. When processed at Better Made Inc. on March 7th, the Lamoka's were reported to have a 1.085 specific gravity and no chip quality defects. The Agtron score was reported to be 71.5. Figure 2 represents a chip quality grade sample conducted on finished product from the Better Made processing run of Lamoka by Michigan State University Potatoes Extension based on MSU evaluation criteria. Figure 3 is a picture of Lamoka just after leveling the fryer on March 7th, Better Made Inc.

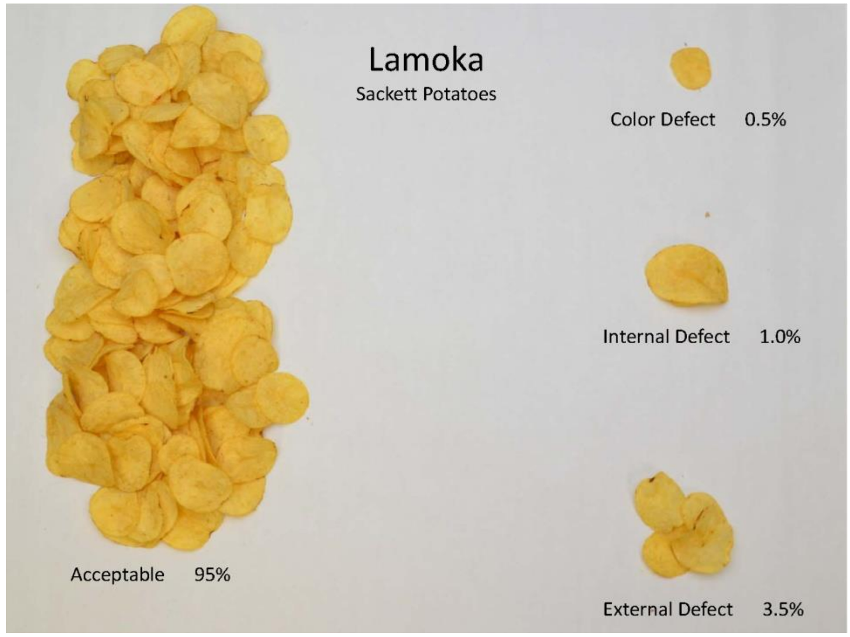


Figure 2. MSU grade sample from bin 1 processed at Better Made, Inc. on 3.7.12


Figure 3. Picture of Lamoka chips just after leaving the fryer at Better Made, Inc. on 3.7.12

Lamoka has exhibited great agronomic quality, such as high yield potential, common scab tolerance and good chip quality in small plot tests. The field production of this lot of potatoes was reported to be similar to other commercial varieties in production at Sackett Potatoes. Encouraging this variety to set good skins before harvest and storage will be important for its commercialization. Lamoka has shown to be a 130 day potato, slightly later than the standard chipping variety Snowden. Managing nitrogen application may also help in ensuring a better skin set on this variety. Overall, this variety has many great qualities and needs to be evaluated in large acre trials for a number of years to better understand its physical and chemical storability.

Bulk Bin 2, Lamoka (NY139)

Figure 1. Techmark-Inc. chip picture, bin 2 Lamoka, 5.16.12

The Lamoka in bulk bin 2 was grown by Sandyland Farms, Howard City, Michigan, located in Montcalm County. The tuber pulp temperature of the Lamoka tubers upon arrival at the storage was 65.0 °F. The sucrose and glucose levels at the time of bin loading was 0.731 (X10) and 0.002 percent, respectively. The tubers were tested and found to be 85 percent black spot bruise free after bin filling. The tuber quality was good, but moderate skin feathering was observed at the time of bin loading.

This bin was loaded on October 11th and was held at 56.0 °F for wound healing until early November. There was only a trace of sugar related chip defects recorded all season for the Lamoka's in this bulk bin which were reported at 2.4 percent in early January 2012. Sugar levels were monitored as the pile was cooled to a target storage temperature of 48.0 °F. This target temperature was reached in early January 2012. The sucrose and glucose levels were at their lowest point in mid-May, just prior to processing at a value of 0.413 percent (X10) and 0.001 percent, respectively. See the Techmark Inc. May 16th generated photo in the upper right corner which correlates to these sugar numbers (Figure 1). Bin 2 was chip processed in mid-May for a chip processing test conducted by the United States Potato Board. The ending pulp temperature was 49.0 °F when shipped on May 16th, 2012 to Utz Quality Foods, Hanover, PA for processing on May 17th. At the time of bin unloading, tuber weight loss was 4.68 percent, with 7.1 percent of the tubers expressing pressure bruise and discoloration under the skin. This variety appears to pressure bruise similarly to other varieties, but the discoloration under the pressure bruise area is observed at a very low incidence level. In this case, the number of pressure bruises with discoloration under the skin was elevated due to the duration of the tubers in storage and high air volume in the storage bin causing a higher percentage of tuber dehydration. When processed at Utz Quality Foods, Inc. on May 17th, the Lamoka's were reported to have a good raw tuber quality. The larger tubers appeared more oval to oblong when compared to Snowden and Atlantic. Some early blight and pressure bruise was evident even after peeling and in the finished chips (Figure 3). No pitted scab was reported. The specific gravity was recorded at 1.098. The Hunter Lab color score was reported to be 60.3. Figure 2 represents a chip quality grade sample taken of finished product from the Utz Quality Foods processing run of Lamoka. The only chip defects reported were the external pressure bruise observed in Figure 3. The pressure bruising is believed to have been caused by high air volume resulting in excess tuber dehydration. Figure 4 is a picture of Lamoka chips that appear to be exhibiting blackheart. This defect has been reported since 2011 as the result of physiological heat stress occurring during the production cycle.

Figure 2. Grade sample from bin 2 processed at Utz Quality Foods, Inc. on 5.17.12

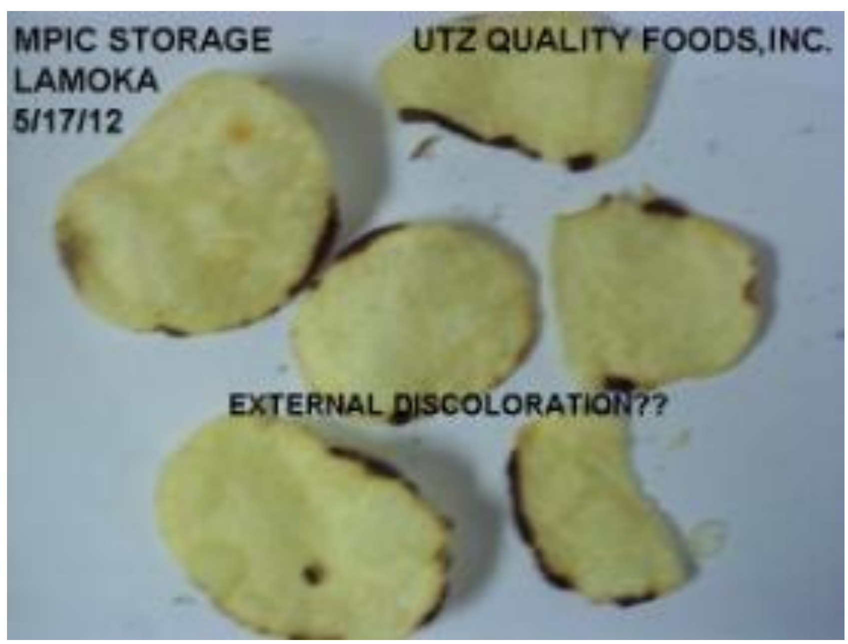


Figure 3. Picture of early blight and pressure bruise in the finished Lamoka chips from Utz Quality Foods, 5.17.12

Lamoka has exhibited great agronomic quality, such as high yield potential, common scab tolerance and good chip quality in small plot tests. Encouraging this variety to set good skins before harvest and storage will be important for its commercialization. Lamoka has shown to be a 130 day potato, slightly later than the standard chipping variety Snowden. Managing nitrogen application may also help in ensuring a better skin set on this variety. Overall, this variety has many great qualities and needs to be evaluated in large acre trials for a number of years to better understand its physical and chemical storability.

Figure 4. Picture of Lamoka chips with what appears to be blackheart 5.17.12

Bulk Bin 3, Lamoka (NY139)

These Lamoka potatoes were produced by Lennard Ag. Co. in Branch Country, Michigan and were harvested on November 7th, 2011. Bin 3 was filled on November 10th, with a tuber pulp temperature of 48 °F. On arrival, the tubers exhibited signs of physical injury and shatter bruising. The tubers were determined to be only 40 percent black spot bruise free after bin loading. The initial sucrose rating was 0.995 percent on November 10th. The pile temperature was warmed to 55.0 °F after bin loading to

Figure 1. Picture sample of Lamoka from bin 3 on 1.4.12

encourage suberization until early December when the pile was cooled to 54.0 °F. The tubers remained at 54.0 °F due to the large amount of stem-end defects and external defects that were present in the chip samples. The sucrose value decreased to 0.415 (X10) percent and the glucose level was 0.012 percent in early January 2012. Fan time and fresh air were maintained at the highest level possible to slow disease spread and encourage tuber respiration in hopes of making the tubers marketable. Figure 1 shows the chip quality during the early part of the storage season. The sucrose and glucose levels were at values of 0.613 percent (X10) and 0.002 percent, respectively, when the bin was shipped for processing in mid-March 2012. See the Techmark Inc. March 12th photo in the upper right corner which correlates to the previously mentioned sugar numbers (Figure 2). The ending tuber pulp temperature was 53.2 °F on March 14th, 2012 when the potatoes were shipped to Better Made, Inc. for processing on March 15th. At the time of bin unloading, tuber weight loss was 7.99 percent, with 6.2 percent of the tubers expressing pressure bruise and discoloration under the skin. No potato raw quality or finished chip quality was reported from Better Made on this load. The tubers were used to make a potato stick product and no further data was collected. The Lamoka variety was able to process a large amount of free sugar that was the result of field stress and cold temperatures. The ability of this variety to process the amount of free sugar that had accumulated was remarkable. The ending chip quality of these potatoes in March 2012, although marginal, was still able to be sold and processed. Lamoka continues to exhibit a strong sugar metabolism and chip quality and this bin and its condition help to exhibit that.

Figure 2. 3.12.12 chip picture of Lamoka just prior to processing on 3.15.12 at Better Made, Inc.

Bulk Bin 4, W2133-1 (Nicolet)

Figure 1. 2.14.12 Techmark Inc. chip picture of Nicolet just prior to processing

W2133-1 is a University of Wisconsin developed variety. In the 2010 on-farm trials, this variety yielded 496 cwt./A US#1. It has a three year US#1 yield average of 490 cwt./A from 2008-2010. This variety also has uniform round tuber type. It exhibits some moderate common scab tolerance. An in-row seed spacing of 10.5 to 11.5 inches is recommended. The tuber set per plant is 10-18 tubers. This variety was not in the 2011 Michigan on-farm variety trials, therefore no recent agronomic data is available.

The W2133-1 potatoes in bin 4 were grown by Walther Farms in St. Joseph county Michigan and were harvested and loaded into storage on October 13th with a pulp temperature of 64.0 °F. The overall size profile of the tubers was small. The potatoes were determined to be 90% bruise free after bin loading. The tubers were cooled to 58.0 °F after arrival and allowed to remain at this temperature to suberize for two weeks. The percent sucrose reading in early November 2011 was 0.894 (x10). The glucose value was 0.001 percent at this same time. After suberization, the tubers were then cooled at 0.2 °F per day until the potatoes reached a pulp temperature of 55.0 °F in early November 2011 at which time the sucrose and glucose levels were reevaluated. In early November, the sucrose value was 0.922 (x10) percent and the glucose was 0.004 percent. The pulp temperature was allowed to cool slightly to 54.6 °F and was held constant at this temperature December 2011 through January 2012. In late-January 2012, the sucrose and glucose reached their lowest levels of the season at 0.372 and 0.001, respectively. At this time, it was determined that the Nicolet's had reached their optimal chip quality and the bin was scheduled for processing at Better Made, Inc. in February. On February 13th, just prior to shipping the sugar levels were recorded to be 0.421 and 0.002. The pile temperature was 54.0 °F on the date of shipping. Figure 1 depicts the chip quality in the Nicolet tubers on the day of bin unloading.

The picture to the right depicts the overall chip quality of this load after processing at Better Made, Inc. on February 15, 2012. Some sugar accumulation, stem-end defect, and pressure bruise are visible in the chip defects. The weight loss in this bin was only 3.17 percent, but 8.4 percent of the tubers had pressure bruise and discoloration under the skin, which was evidenced in the external chip defects (Figure 2). The W2133-1 processed acceptably at Better Made. The specific gravity of the tubers at the time of processing was 1.085 and the total defect score recorded at the plant on February 15th was 6.05 percent, 3 percent lower than depicted above in Figure 2. Overall, this variety has good chip quality and processing potential into mid-season storage. Yield potential can be variable and is potentially negatively affected by a late vine maturity. The lateness of this variety appears to affect its' tuber size and yield potential as well. Managing nitrogen inputs and providing adequate length of growing season are important factors in maintaining the chip quality of W2133-1. W2133-1 consistently chips into late March and early April in most years.

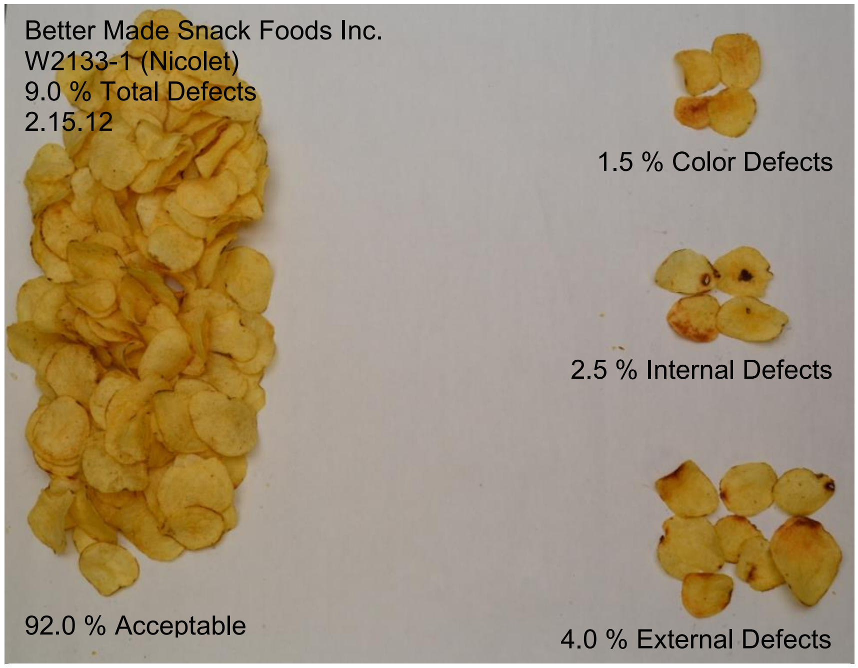


Figure 2. Chip picture taken by MSU of Nicolet processed at Better Made, Inc. 2.15.12

Bulk Bin 5, MSH228-6

Figure 1. 1.30.12 Techmark Inc. chip picture of MSH228-6 just prior to shipping for dehydration

MSH228-6 is a variety from the Potato Breeding and Genetics program at Michigan State University. This variety has good tuber size with an oval to round appearance. The common scab tolerance of this variety is good, similar to Lamoka (NY139) and better than Snowden. The number of tubers set per plant for MSH228-6 is low, from six to ten tubers on average. A close in-row seed spacing is beneficial in increasing tuber yield per acre for this variety. The US#1 yield for this variety is 364 cwt./A over five years from 2007-2011. The specific gravity average ranges from 1.076 to 1.085 in Michigan. The MSH228-6 in bin 5 was grown in Branch county, Michigan by Lennard Ag. Co. The storage was filled on November 10th with a pulp temperature of 48.0 ℉. The variety was evaluated to be 48 percent black spot bruise free after bin loading. Mechanical damage and shatter bruising was evident in the potatoes upon arrival.

The variety was warmed to 55 ℉ after arrival to encourage wound healing and increase the respiration of what appeared to be cold induced sugar accumulation. In early November, bin 5 recorded a 1.348 (X10) percent sucrose and a 0.008 percent glucose level which led the Storage and Handling Committee to be very concerned about the future processing quality of this bin. In addition, it appeared that there was a large amount of stem-end defect, dry rot and pinkeye present that were causing a high percentage of external chip defects. The pile was maintained at 55 ℉ to encourage the metabolism of free sugar. In late-November, the percent sucrose and glucose levels remained high at 1.032 and 0.018, respectively. Sucrose levels decreased and stabilized December 2011 through January 2012, but glucose remained high throughout January 2012, ranging from 0.017 to 0.019 percent. The varieties’ sucrose value decreased to its lowest point of 0.593 in late-January, 2012. The glucose level in the tubers also reached its lowest levels in late-January at 0.005 percent. Figure 1 depicts the chip quality on January 30th as recorded at Techmark, Inc. A significant amount of stem-end defect was evident, as well as, the dry rot and pinkeye causing a tremendous amount of external defects in the finished chips. The storage committee recognized that it was impossible to improve the external chip defect level and decided to ship the bin of MSH228-6 to a dehydration plant in early February 2012. At the time of bin unloading, tuber weight loss was 3.31 percent, with 3.6 percent of the tubers expressing pressure bruise and discoloration under the skin.

The cold harvest condition made the MSH228-6 tubers susceptible to physical damage which led to a significant amount of tuber infection by the dry rot pathogen. This high incidence of dry rot infection was instrumental in this variety having poor chip quality. The sugar levels in the tubers did make some improvements, but the severe stem-end defect remained. The Lamoka's in bin 3 experienced these same harvest conditions and were still able to be processed. The Lamoka's were not without defect, but appeared to process the free sugars better. The bin 3 Lamoka is also had some severe stem-end defect, but were free from the dry rot and pinkeye. On average, MSH228-6 has struggled to outperform standard varieties in Michigan. The future of this variety may be realized through further testing in other geographic regions of the US by the United States Potato Board Fast Track Program.

Bulk Bin 6, MSQ070-1

MSQ070-1 is a variety from the Potato Breeding and Genetics program at Michigan State University. In the 2011 on-farm trials, this variety yielded 310 cwt./A US#1. It has a three year US#1 yield average of 339 cwt./A from 2009-2011. This variety is uniform round in type. It exhibits some moderate common scab tolerance. The variety has tremendous vine vigor and is late to mature. The variety has shown to have late blight tolerance as well.

Figure 1. 2.14.12 Techmark Inc. chip picture of MSQ070-1 just prior to shipping to Better Made, Inc. for processing

The potatoes in bin 6 were grown by Walther Farms, Three Rivers, MI., and were harvested and loaded into storage on October 24th, 2011 with a pulp temperature of 54.5 °F. The tubers were determined to be 93% bruise free after bin loading. Upon arrival, the tubers were evaluated for sugar concentration and the sucrose and glucose levels were found to be elevated. On October 24th, the sucrose and glucose levels were 1.176 (X10) and 0.007 percent, respectively. The vines

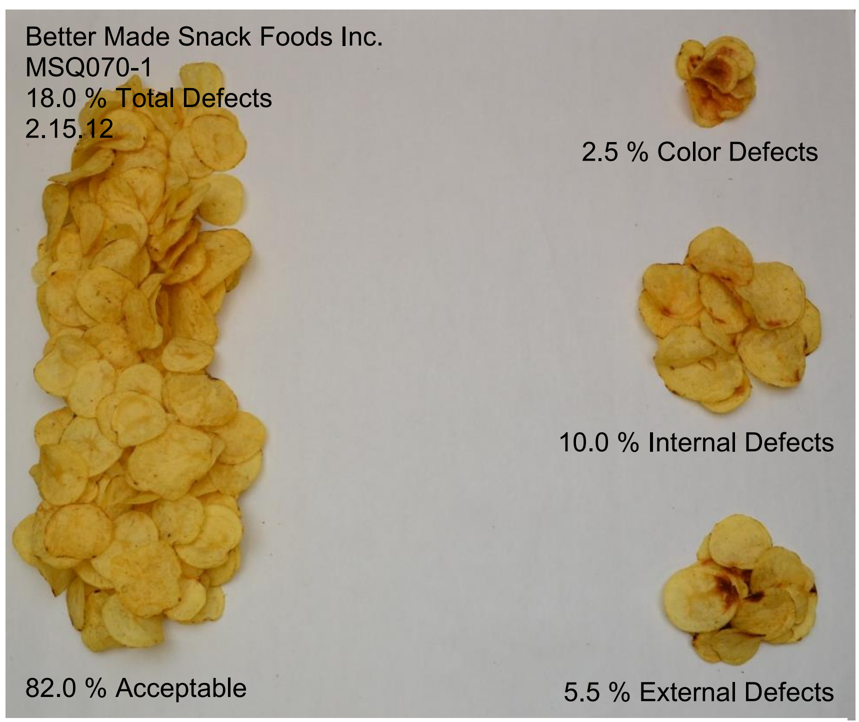


Figure 2. Chip picture taken by MSU of MSQ070-1 processed at Better Made, Inc. 2.15.12

were very green in the field in late September and the plot of MSQ070-1 was allowed to mature for three weeks past the optimal vine kill period to encourage natural senescence. It appears, based on pre-harvest panel data and this initial storage data, that the tubers were immature at the time of harvest. The storage bin temperature was maintained at 55.0 °F to encourage respiration of the simple sugars present in the tubers. In early-January 2012, the tubers reached their lowest sucrose value of 0.679 (X10) percent, but the glucose was recorded at its highest level at this same time period with a value of 0.024 percent. The glucose levels remained variable for the remainder of the storage season but never rose to this level again. Figure 1 shows the chip quality of the MSQ070-1 tubers just prior to processing on February 13th, 2012. The sucrose level was 1.140 (X10) percent and the glucose was 0.002 percent on February 13th. As a result of the sugar trend continually rising in early to mid-February, the bin was slated for processing. At the time of bin unloading, tuber weight loss was 8.22 percent, with 0.0 percent of the tubers expressing pressure bruise and discoloration under the skin.

This bin of MSQ070-1 was processed at Better Made, Inc. on February 15th, 2012. Figure 2 shows the chip quality from the MSQ070-1 tubers after processing. The specific gravity of the tubers at the time of processing was 1.084. Better Made recorded a total percent defect score of 10.5 and an Agtron score of 65.4. The MSU chip sample in Figure 2 recorded an 18 percent total defect score. A much higher internal defect score was recorded at MSU in the finished chips than was reported at Better Made. It appears that MSQ070-1, although it has good common scab tolerance and late blight resistance, has a vine maturity that is much too late for production in the southern counties of the state of Michigan. Additional evaluation of this variety under longer growing conditions may be of value.

Funding: MPIC and Industry

Effect of Stadium applied post-harvest for control of naturally occurring tuber diseases from Michigan potato fields, demonstration trials 2010 to 2012.

W. W. Kirk, C. Long, P. Somohan, A. Rojas and R. L. Schafer. Department of Plant, Soil and Microbial Science. MSU. East Lansing, MI 48824.

Materials and Methods

2010 to 2011

Potato tuber samples from five different fields (1, 2, 3, 4, & 5) were analyzed to determine their disease risk. Hot-box testing and molecular detection using PCR multiplex were used for the analysis. Hot-box tests exposed the tubers to humid and warm (35°C) conditions for 5 days, while PCR multiplex is based on the use of multiple primers to detect different pathogens. Tubers from field 5 had the highest disease incidence, thus chosen for a storage trial involving treatment with a three-way mixture of azoxystrobin, fludioxonil, and difenoconazole.

Tubers from field 5 were stored in two bins; one treated with the three-way mixture of azoxystrobin, fludioxonil, and difenoconazole, and the other one was not treated. Samples of 100 tubers from each bin were obtained monthly from September 2010 to April 2011. The samples were taken to the lab to determine disease incidence by hot-box testing and PCR multiplex. Upon arrival in the lab, the samples were incubated in the warm (30˚C) and humid hot-box for 5 days. These conditions were conducive for disease development. After the incubation, the tubers were visually evaluated for blemish diseases, presence of bruises, or defects that could indicate early stages of disease development. The disease severity was rated in a severity scale of 0 to 4 (where 0= no bruises or symptoms and 4= diseased tuber with advanced symptoms); 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. Increasing index values indicated the degree of severity and thus converted to a scale from 0 - 100.

Ten symptomatic tubers were further sampled from the tubers incubated in the hot-box for pathogen detection. PCR multiplex was performed for three different pathogens in a single reaction. The diseases were Pythium leak (*Pythium ultimum*), soft rot (*Pectobacterium carotovorum* subsp. *atroseptica*), and pink rot (*Phytophthora erythroseptica*). Five plugs were randomly taken from each of the ten tubers sampled for extraction of total DNA. A DNA- extraction method was used as described by Allen et al. (2006), which uses CTAB to reduce DNA degradation and interference during PCR. Three pairs of primers were used for the detection (Table 1), and the PCR conditions standardized to initial denaturation at 94˚C for 2 min, followed by 35 cycles of 94˚C for 1 min, 58˚C for 1min, and 72˚C for 1 min, and final extension at 72˚C for 10 min. PCR products were visualized in agarose gels (1%) for the detection of the specified band sizes. Samples were rated by presence or absence of the expected bands (Table 1).

Table 1. Primers used for PCR multiplex detection of storage rot potato pathogens.

Pathogen	**Primer sequences**	**Expected band**	**Reference**
Pythium ultimum	Pu1F1 GACGAAGGTTGGTCTGTTG Pu2R1 CAGAAAAAGAAAGGCAAGTTTG	307 bp	(Cullen et al. 2007)
Phytophththora erythroseptica	Pery2F1 TGGTGAACCGTAGCTGTGCTA Pery2R1 CGCCGAAGCGCACACAACG	135 bp	(Cullen et al. 2007)
Pectobacterium carotovorum subsp. atroseptica	Eca1F CGGCATCATAAAAACACG Eca2R GCACACTTCATCCAGCGA	690 bp	(De Boer & Ward 1995)

2011 to 2012

The same protocol was followed as above. However, the main pathogen detected was Pythium and tubers with the highest risk were selected for the demonstration.

Results

2010 to 2011

Tubers from five fields were analyzed by hot-box test and PCR multiplex to determine the one with higher disease risk. Fields 1, 2, and 5 showed the higher disease index, which meant that tubers had symptoms or bruises indicating the presence of disease (Fig 1A). However, field 5 had the highest disease incidence, mainly Pythium leak, as confirmed by the PCR multiplex (Fig 1B), thus selected for the storage trial.

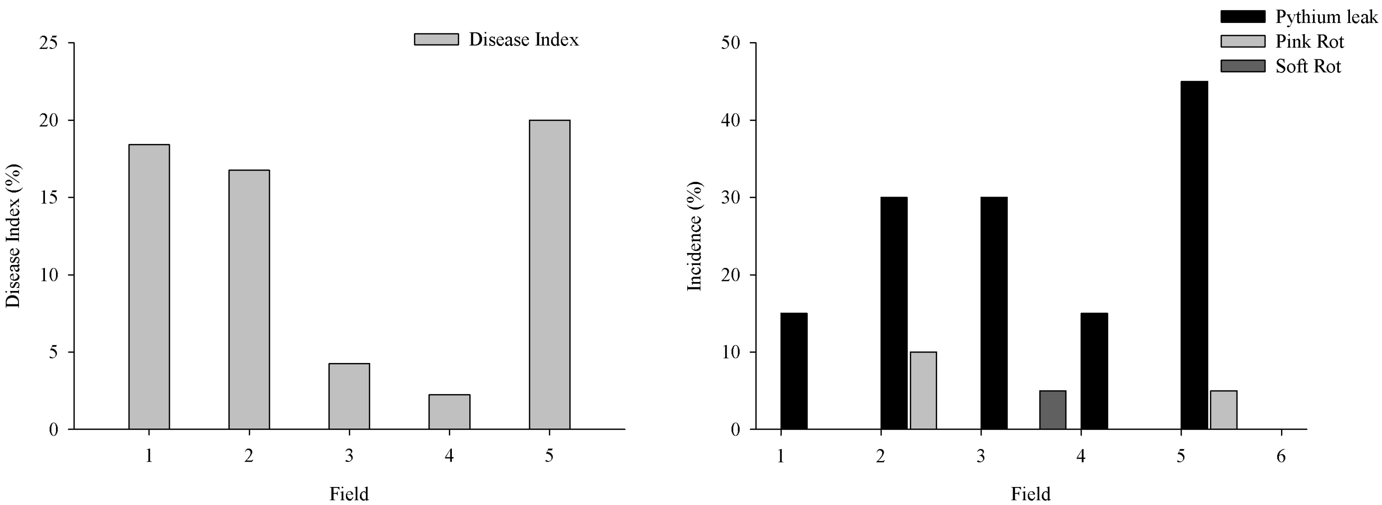


Figure 1. (A) Disease index of tubers rated in scale from 0 to 100 after hot-box test from five different fields. (B) Disease incidence based on positive results obtained from PCR multiplex of Total DNA of tubers (n=20) sampled from each field.

Samples of 100 tubers were obtained from the storage bins, either treated with the three-way mixture of azoxystrobin, fludioxonil, and difenoconazole, or not treated (control). A total of 7 samples were analyzed using the hot-box test and PCR multiplex during the 8-months period. The PCR multiplex was able to determine the presence of three different pathogens causing tuber rots in storage. The molecular detection was visualized by ethidium bromide-stained gels (Fig 2), where positive controls were used as references, establishing the presence/absence of the pathogens in the tissue.

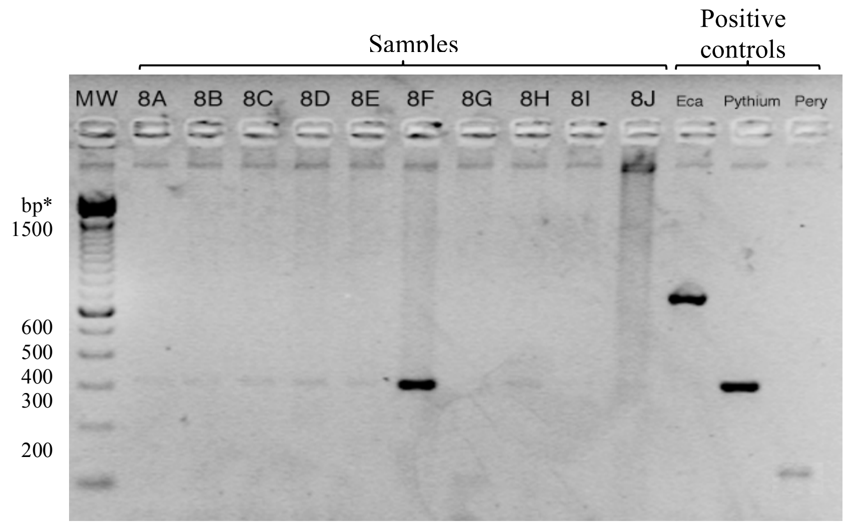


Figure 2. Ethidium bromide-stained agarose gel of the PCR multiplex for detection of storage rot pathogens of potato (*P. ultimum, P. erythroseptica* and *P. carotovorum*) of 8 samples, including positive controls. MW = Molecular weight marker. * bp = base pairs.

The results from hot-box were presented as disease index, indicating that the untreated bin had relatively higher disease index than the treated bin during the visual assessment (Fig 3A). It is important to remark that hot-box test considered any bruise or symptom during the rating. On the other hand, PCR multiplex is sensitive and specific to presence/absence of the pathogen itself. PCR multiplex results showed a higher disease incidence on the untreated bin, Pythium leak being the most common disease present during the storage trial (Fig 3B). However, some samples did show the presence of the three diseases included in this study; for instance, the sample obtained in February showed higher disease index for the untreated bin, and high disease incidence on both bins as revealed by PCR multiplex.

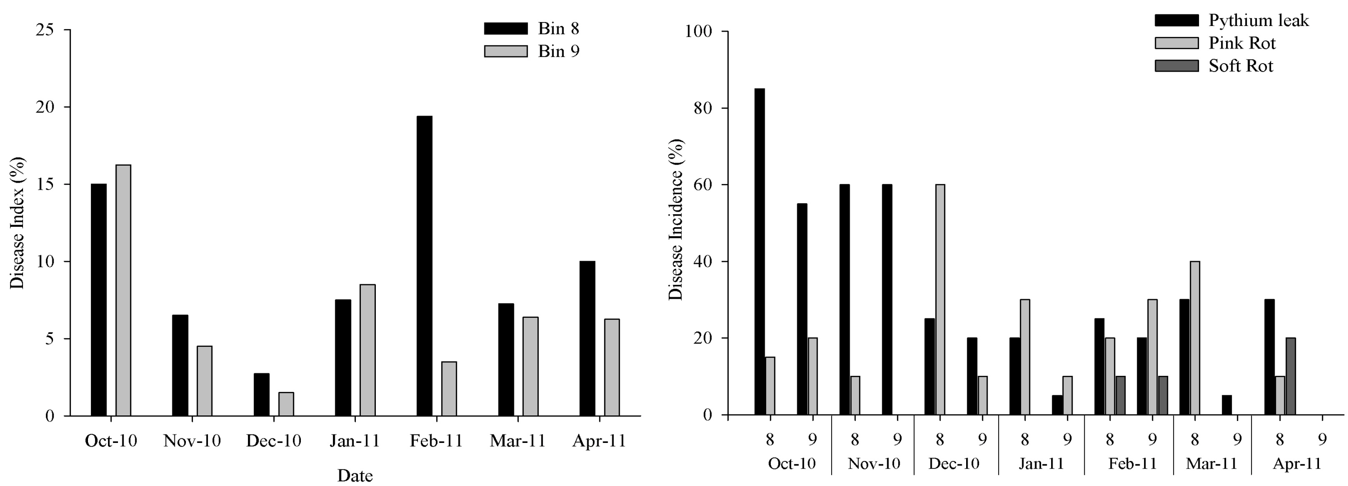


Figure 3. (A) Disease index of tubers rated in scale from 0 to 4 after hot-box test from samples collected from untreated (8) and treated (9) bins. (B) Disease incidence based on positive results obtained from PCR multiplex of total DNA of tubers (n=20) sampled.

2011-2012

Tubers from five fields were analyzed by hot-box test and PCR multiplex to determine the one with higher disease risk. The field (cv. Pike) with the highest disease incidence, mainly Pythium leak, as confirmed by the PCR multiplex was selected for the storage trial. The results from hot-box tests were presented as disease incidence and a severity index, indicating that the untreated bin had relatively higher disease index than the treated bin during the visual assessment (Fig 4).

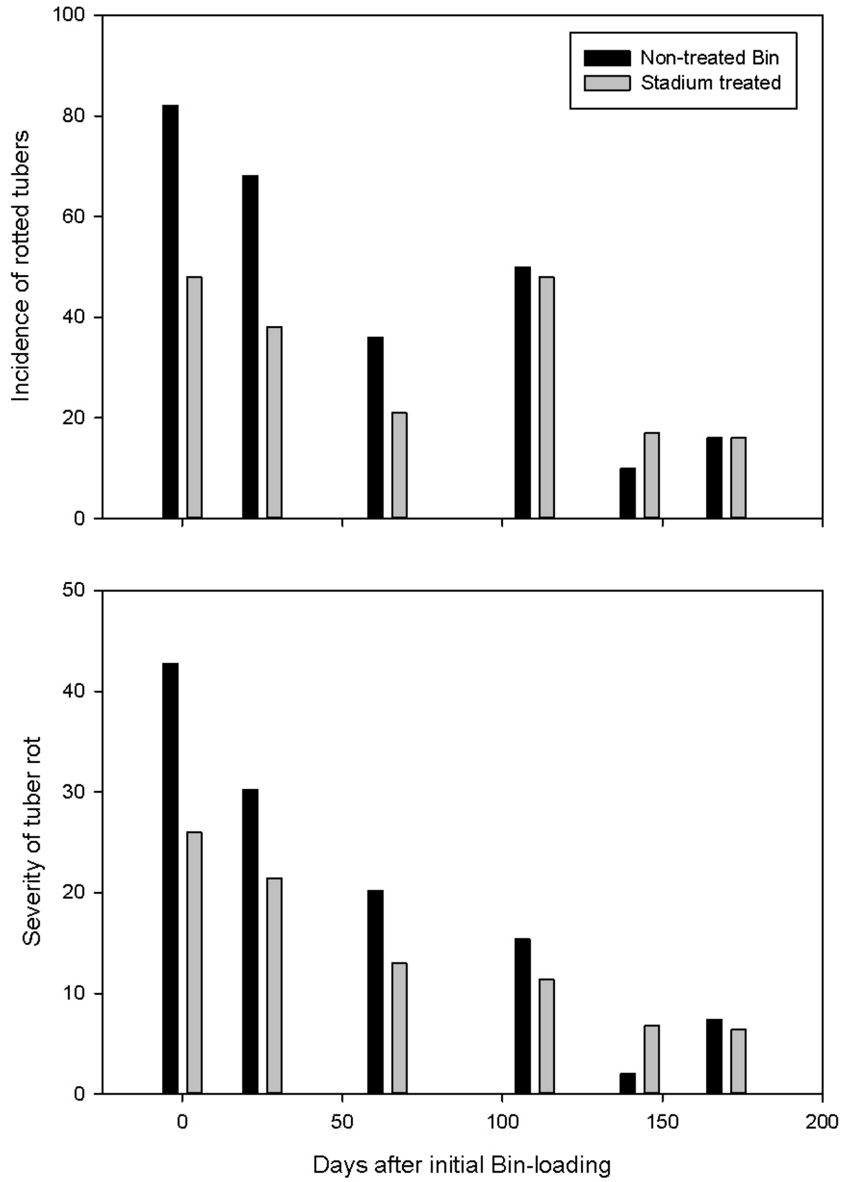


Figure 4. Disease incidence and severity index of tubers rated on severity scale from 0 to 4 then converted to a 0-100 index after hot-box test from samples collected from untreated (8) and treated (9) bins.

In general, treatment with the three-way mixture of azoxystrobin, fludioxonil, and difenoconazole reduced the impact of storage rot diseases on potato, having a long term effect, which was evident in the last two samples collected (March and April) in 2010/11, where no disease incidence was observed by

PCR multiplex. Nonetheless, visual assessment after hot-box test indicated some bruises or defects were observed on the tubers as shown by the disease index; these are probably result of initial stages of disease controlled by the treatment or may not be related to disease. Pythium leak was the most persistent disease during the study, followed by pink rot. In the 2011/12 trials, the Stadium treated demonstration bin had decreased incidence and severity of overall tuber rot early in the season in comparison to lower differences and overall incidence later in the storage period.

No statistical analyses were conducted on these data as this was purely a demonstration trial and not set up with a rigorous experimental protocol.

References

Allen, G.C. et al., 2006. A modified protocol for rapid DNA isolation from plant tissues using cetyltrimethylammonium bromide. *Nature protocols*, 1(5), pp.2320-2325.

Cullen, D.W. et al., 2007. Development and validation of conventional and quantitative polymerase chain reaction assays for the detection of storage rot potato pathogens, *Phytophthora erythroseptica, Pythium ultimum* and *Phoma foveata*. *Journal of Phytopathology*, 155(5), pp.309-315.

De Boer, S. & Ward, L., 1995. PCR detection of *Erwinia carotovora* subsp. *atroseptica* associated with potato tissue. *Phytopathology*.