Michigan State University
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In Cooperation With
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Michigan Potato Research Report
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Michigan Potato Industry Commission

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MICHIGAN POTATOES
MICHIGAN POTATO INDUSTRY COMMISSION

January 12, 2018

To all Michigan Potato Growers and Shippers,

Research is at the core of the work that continues on the part of the industry. Through research we are able to test, to study, and to advance Michigan potato production. As crop research expands, we learn more about diseases and storage management. We are able to look at potatoes and their resistance to insects. We can look at the levels of individual elements in a potato and learn more about their relationship with one another, creating a better vegetable in the process. Through research we are able to achieve so many things.

The following research report was compiled with the help of the Michigan State University's AgBioReseach and Michigan State University Extension. On behalf of all parties, we are proud to present you with the results of the 2017 potato research projects.

We would like to thank our many suppliers, researchers, and all others involved in making this year's research season a success. As the industry faces new challenges and strives for the perfect potato, we are inspired by the level of cooperation in the industry and look toward future success.

Sincerely,

Michael R. Wenkel
Executive Director

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2017 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2017 Potato Research Report contains reports of the many potato research projects conducted by Michigan State University (MSU) potato researchers at several locations. The 2017 report is the 49th 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), Project GREEEN and numerous other sources. The principle source of funding for each project has been noted in 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 goes to Mathew Klein for his management of the MSU Montcalm Research Center (MRC) and the many details which are a part of its operation. We also want to recognize Katrina Zavislan, MSU for organizing and compiling this final draft.

WEATHER

The overall 6-month average maximum and minimum temperatures during the 2017 growing season were nearly identical to the 15 year averages at 74°F and 50°F respectively (Table 1). The average maximum temperatures during April and September was slightly higher than the 15-year average by 1°F. Extreme heat events were about average in 2017 (Table 3) with 14 hours over 3 days in which temperatures exceeded 90 °F during the entire summer. Extreme high nighttime temperatures were slightly lower in 2017 compared to 2016 with only 80 hours over 18 days exceeding 70 °F. The 2017 nighttime extreme temperatures events were the second lowest recorded across the seven year average.

Rainfall for April through September was 15.78 inches, which was 0.86 inches below the 15-year average (Table 2). A total of 7.2 inches of irrigation water over 17 application timings was applied to MRC 1 during the time period of late May to early September. In general, precipitation during the spring (April-June) was above average, while late season precipitation (July-September) was below average.

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		Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
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	33	67	40	77	56	80	58	80	54	73	50	73	49
2009	56	33	67	45	76	54	75	53	76	56	74	49	71	48
2010	64	33	70	49	77	57	83	62	82	61	69	50	74	52
2011	53	33	68	48	77	56	85	62	79	58	70	48	72	51
2012	58	33	73	48	84	53	90	62	82	55	74	46	77	50
2013	51	33	73	48	77	55	81	58	80	54	73	48	73	49
2014	55	33	68	45	78	57	77	54	79	56	72	47	72	49
2015	58	33	71	48	76	54	80	56	77	57	77	54	73	51
2016	53	32	70	45	78	53	82	60	85	60	78	54	74	51
2017	**61**	**39**	**67**	**44**	**78**	**55**	**81**	**58**	**77**	**54**	**77**	**50**	**74**	**50**
15-Year Average	58	34	68	46	78	55	81	58	80	57	74	49	73	50

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
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
2013	7.98	4.52	2.26	1.35	4.06	1.33	21.50
2014	4.24	5.51	3.25	3.71	1.78	2.35	20.84
2015	3.71	2.96	4.79	1.72	2.42	3.9	19.5
2016	2.25	2.77	1.33	3.42	5.35	3.05	18.17
2017	**4.45**	**1.98**	**6.37**	**0.92**	**1.36**	**0.70**	**15.78**
15-Year Average	2.94	3.23	2.82	2.64	2.82	2.20	16.64

Table 3. Seven-year heat stress summary (from May 1st – Sept. 30th)*

Year	Temperatures > 90°F		Night (10pm-8am) Temperatures > 70°F	
	Hours	Days	Hours	Days
2011	14	4	174	32
2012	70	15	143	30
2013	14	3	140	28
2014	0	0	58	15
2015	3	1	66	22
2016	10	3	147	31
2017	**14**	**3**	**80**	**18**
Average	18	4	115	25

GROWING DEGREE DAYS

Table 4 summarizes the cumulative growing degree days (GDD) for 2017 while providing historical data from 2005-2017. GDD are presented from May 1st – September 30th using the Baskerville-Emin method with a base temperature of 40 °F. The total GDD base 40 by the end of September in 2017 was 3695 (Table 4), which is 80 GDD lower than the 13-year average of 3775.

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

Year	May	June	July	August	September
2005	419	1358	2289	3187	3906
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	637	1421	2334	3179	3798
2014	522	1340	2120	2977	3552
2015	604	1353	2230	3051	3789
2016	547	1318	2263	3274	4053
2017	**480**	**1279**	**2202**	**2990**	**3695**
Average	552	1333	2258	3132	3775

*2005-2017 data from the weather station at MSU Montcalm Research Center “Enviro-weather”, Michigan Weather Station Network, Entrican, MI.

PREVIOUS CROPS, TILLAGE AND FERTILIZERS

The general potato research area utilized in 2017 was Montcalm Research Center property in the field referred to as 'MRC1'. This acreage was planted to oats in 2016 with crop residue disked into the soil. In the spring of 2017, the recommended rate of potash was broadcast applied following deep-chisel plowing. The ground was field cultivated and direct planted to potatoes. The area was not fumigated with Vapam prior to potato planting, but Vydate® and Verimark® were applied in-furrow at planting.

The soil test analysis for the general crop area (taken in April 2017) was as follows:

	lbs/A			
pH	P	K	Ca	Mg
6.8	356 (178 ppm)	228 (114 ppm)	1218 (609 ppm)	188 (94 ppm)

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

Application	Analysis	Rate	Nutrients ($N-P_2O_5-K_2O$-Ca/Mg/S/Zn)
Broadcast at plow down	0-0-22-11Mg-22S 0-0-0-21Ca-16S 0-0-0-21Ca-12Mg 10%B 0-0-62 0-0-0-9Zn	200 lbs/A 150 lbs/A 300 lbs/A 6 lbs/A 350 lbs/A 1 qt/A	0-0-44-22Mg-44S 0-0-0-32Ca-24S 0-0-0-63Ca-36Mg 0.6 lb. B 0-0-217 0.3 lb. Zn
At-planting	28-0-0 10-34-0	24 gpa 12 gpa	72-0-0 14-49-0
At-cultivation	28-0-0 10-34-0	24 gpa 12 gpa	72-0-0 14-49-0
At-hilling	46-0-0	120 lbs/A	55-0-0
Late side dress (late varieties)	46-0-0	100 lbs/A	46-0-0

HERBICIDES AND PEST CONTROL

A pre-emergence application of Linex at 1.25 quarts/A and Brawl II at 1.0 pints/A was made in late May.

Verimark and Vydate were applied in-furrow at planting at a rate of 13.5 fl oz/A and 2 quarts/A, respectively.

Bravo (1.5 pts/A), Koverall (2 lbs/A) Manzate Pro Stick (1 or 2 lbs/A), Tanos (0.5pts/A) and Vertisan (1.5pts/A) fungicides were applied alone or in combination on twelve dates between June and mid-September.

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

2017 MSU POTATO BREEDING AND GENETICS RESEARCH REPORT
January 2018

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INTRODUCTION

At Michigan State University, we have been dedicated to developing improved potato varieties for the chip-processing and tablestock markets since 1988. The program is one of four integrated breeding programs in the North Central region supported through the USDA/NIFA Potato Special Grant. At MSU, we conduct a comprehensive multi-disciplinary program for potato breeding and variety development that integrates traditional and biotechnological approaches to breed for disease and insect resistance that is positioned to respond to scientific and technology opportunities that emerge. We are also developing more efficient methods to breed improved potato varieties.

In Michigan, variety development 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 Agronomy 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, PVY resistance, late blight resistance and higher specific gravity). I am happy to see the increase in scab, late blight and PVY resistance in the breeding material and selections. Through the USDA/AFRI SolCAP project we developed a new set of DNA genetic markers (8,303) called SNPs that are located in the 39,000 genes of potato. We now have expanded the number of SNPs to 22,000 and are further expanding the number of SNPS to 35,000 on the next version of the array. This SolCAP translational genomics project has finally giving us the opportunity to link genetic markers to important traits (reducing sugars, starch, scab resistance, etc.) in the cultivated potato lines and then breed them into elite germplasm. The SNPs also allow us to accurately fingerprint the varieties (DNA ID database). 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, Potatoes USA (USPB) is supporting national early generation trials called the National Chip Processing Trial (NCPT) which will feed lines into the SNaC (SFA) trials and also fast track lines into commercial testing. We are taking advantage of the NCPT fast track to have seed increased for promising chip-processing lines. We also have funding to develop genome editing technologies that may not be classified as genetic engineering through a USDA/BRAG grant. This technology can be used to introduce lower sugars, bruising and asparagine. We also hope to use the technology to edit late blight resistance genes. We also have a USDA/AFRI diploid breeding grant to develop some foundational diploid breeding germplasm. In 2015 we were awarded the USAID grant to generate late blight resistance potatoes for Bangladesh and Indonesia. This project brings us into cutting edge GM work with Simplot and the International Potato Center. Lastly we have NSF-funded grants to better understand the potato genome and study wound-healing in potato. 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 advanced technologies with 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. 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. In 2016 year we constructed a greenhouse to expand our breeding and certified minituber seed production. This greenhouse is at the MSU Crops facility on south campus. In 2016 we began to upgrade the grading line and we would like to complete this process in 2018 then expand storage capacity in the near future.

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 2017 field season, progeny from about 400 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 2017 harvest, over 1,000 selections were made from the 40,000 seedlings produced. In addition, about 500 first year selections from elite chip-processing crosses segregating for PVY resistance were made. All potential chip-processing selections will be tested in January and April 2018 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 200 and 80 selections were made, respectively; based upon chip quality, specific gravity, scab resistance, late blight resistance and DNA markers for PVY and Golden nematode resistance. Selection in the early generation stages has been enhanced by the incorporation of the 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 are now using a cryotherapy method that was developed in our lab to remove viruses. We feel that this technique predictably as well as quickly remove virus from tissue culture stocks. Our results show that we are able to remove both PVY and PVS from lines, but PVS can be difficult to remove in certain lines. We tested the removal of PLRV and succeeded. Over 2000 lines are maintained in tissue culture for the breeding and genetics program.

Chip-Processing

Over 80% of the single hill selections have a chip-processing parent in their pedigree. Our most promising advanced chip-processing lines are MSX540-4 (scab, late blight and PVY resistant) MSV313-2 (scab resistant), MSW485-2 (late blight resistant), MSV358-3 (scab resistant), MSW075-2 (scab resistant), MSZ222-19 (scab resistant), MSZ242-09 (scab resistant) and MSZ219-1, MSZ219-13 and MSZ219-14 (all three sibs are scab, late blight and PVY resistant). 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. Manistee was licensed to Canada and Chile. MSR127-2, Saginaw Chipper and MSX540-4 are being tested in Australia.

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 selecting some pigmented skin and tuber flesh lines that fit some specialty markets. There is also interest in some additional specialty mini-potatoes for the "Tasteful selections" market. We have interest from some western specialty potato growers to test and 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 round white, red-skin, and improved Yukon Gold-type yellow-fleshed potatoes. Some of the tablestock lines were tested in on-farm trials in 2017, while others were tested under replicated conditions at the Montcalm Research Center. Promising tablestock lines include MSV093-1, MST252-1Y, MSV179-1, MSW343-2R, MSX569-1R and MSX324-1P. We have a number of tablestock selections with late blight resistance (MSS576-5SPL and MST145-02). MSZ109-8PP and MSZ109-10PP are purple-fleshed chippers with deep purple flesh, round shape and attractive skin. Jacqueline Lee was licensed to Australia and is being grown in Central America for its late blight resistance. Spartan Splash, Blackberry and our virus resistance Red Marker potato are being marketed in the specialty markets.

Disease and Insect Resistance Breeding

Scab: In 2017 we had two locations to evaluate scab resistance: a commercial field with a history of severe scab infection (Sackett Potatoes) and a highly infected site at the Montcalm Research Center in the commercial production area. The commercial site and the Montcalm Research Center both gave us high infection levels. The susceptible checks of Snowden and Atlantic were highly infected with pitted scab. Promising resistant selections were MSV313-2, MST252-1Y, MSV179-1, MSX324-1P, MSW474-01, MSZ219-1, MSZ219-13, MSZ219-14, MSZ222-19 as well as the Z-series selections from the commercial scab site. 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. The MRC scab site was used for assessing scab susceptibility in our advanced breeding lines and early generation material and is summarized below (Figure 1). All susceptible checks were scored as susceptible.

Fig. 1. Scab Disease Nursery Ratings from MRC trials

Trial	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	Total
Variety Trial	0	24	75	69	58	30	3	3	0	262
Early Generation	3	46	52	69	64	29	11	4	1	279
Diploid	2	9	27	27	30	11	5	1	0	112

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. The ability to select under commercial settings at Sackett Potatoes is accelerating our ability to select for scab resistant varieties. MSZ219-1, MSZ219-13, MSZ219-14, MSZ022-07, MSZ222-19 and MSZ242-09 are some of the first scab resistant chippers to advance through this effort.

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. In 2017 we conducted late blight trials at the Clarksville Research Center. We inoculated with the US23 genotype and the results are summarized in Figure 2. Over 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.

Fig. 2. Advanced Breeding lines with foliar late blight resistance to US23

LINE	N	RAUDPC[1] MEAN	*Pedigrees go w/ RAUDPC Sort* Female	Male
A02507-2LB (Payette)	3	0.2	EGAO9702-2	GemStar Russet
MSW121-5R	3	1.2	MSM182-1	NDTX4271-5R
MSY474-8	3	1.5	MSM182-1	Haig Ind 98
MSW464-3	3	1.6	MSM246-B	MSR102-3
MSW324-01	3	2.1	MSQ070-1	Marcy (NY112)
MSZ464-3	3	2.1	MSQ070-1	Alca Tarma
MSW092-1	3	2.2	MSL106-AY	Montserrat
MSZ562-4	3	2.8	Muruta	MSL211-3
MSZ219-13	3	2.9	Saginaw Chipper (MSR061-1)	MSR127-2
Ciklaman	3	3.2	I 71 17 6	Magyar rozsa
MSU088-01	3	3.3	MSK061-4	Missaukee (MSJ461-1)
MSU016-2	3	3.5	Boulder (MSF373-8)	MSN105-1
MST148-3	3	3.7	MSI152-A	Yukon Gold
MSX497-02	3	5.1	MSQ131-A	MSL268-D
MST145-02	3	5.6	MSI152-A	MSL211-3
MSV403-3	3	6.7	MSQ070-1	MSN099-B
MSZ219-46	3	6.7	Saginaw Chipper (MSR061-1)	MSR127-2
Musica	3	6.7	CMK1993-042-055	Lady Christl
MSZ424-1R	3	6.7	NY121	MSR217-1R
MSZ219-44	3	7.1	Saginaw Chipper (MSR061-1)	MSR127-2
MSX497-06	2	7.6	MSQ131-A	MSL268-D
MSW128-2	3	8.9	MSM171-A	MSQ176-5
MSZ219-01	3	9.7	Saginaw Chipper (MSR061-1)	MSR127-2
W13014-5rus	3	9.8		
MSZ219-14	3	9.8	Saginaw Chipper (MSR061-1)	MSR127-2
MSW496-1RUS	3	10.1	Classic Russet (A95109-1Rus)	W1879-1RUS
MSZ263-4	3	10.3	MSU088-1	McBride (MSJ126-9Y)
MSV235-2PY	1	10.5	Malinche	Colonial Purple (MSN215-2P)

PVY: We are using PCR-based DNA markers to select potatoes resistant to PVY. The gene is located on Chromosome 11. In our first round we made crosses in 2013 to generate over 7,000 progeny segregating for PVY resistance. Each year since 2013 we are making new crosses, making selections and expanding the germplasm base that has PVY resistance (Fig. 3). We are also using DNA markers to also screen for PVX resistance, PLRV resistance, late blight resistance and Golden nematode resistance.

Fig. 3 PVY resistant selections in the breeding program

Year	Family	PVYR
YR0	MSFF	111 Families
YR1	MSEE	466 Selections to DNA screen
YR2	MSDD	36 Selections
YR3	MSCC	11 Selections
YR4	MSBB	23 Selections

MSU Lines with Commercial Tracking

Manistee (MSL292-A)

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

Strengths: Manistee is a chip-processing potato with an attractive round appearance with shallow eyes. Manistee has a full-sized vine and an early to mid-season maturity. Manistee 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.

Saginaw Chipper (MSR061-1)

Parentage: Pike x NY121
Developers: Michigan State University and the Michigan Agricultural Experiment Station
Plant Variety Protection: Trademark

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.

MSV093-1Y

Parentage: McBride x MSP408-14Y
Developers: Michigan State University and the MSU AgBioResearch.
Plant Variety Protection: To Be Applied For

Strengths: MSV093-1Y is a high yield potential yellow-flesh breeding line with an attractive, round tuber shape. This line has demonstrated excellent high yield potential in replicated trials at the MSU Montcalm Research Center and on grower field trials throughout Michigan. This yellow flesh line has excellent internal quality (few defects) and a low incidence of blackspot bruise. MSV093-1Y also has moderate scab tolerance. MSV093-1Y has a strong vine and a mid-early season maturity.

Incentives for production: High yield potential with an attractive tuber shape with good yellow flesh with excellent internal quality.

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.

MSX540-4 (Mackinaw)

Parentage: Saginaw Chipper x Lamoka
Developers: Michigan State University and the MSU AgBioResearch.
Plant Variety Protection: To Be Applied For.

Strengths: MSX540-4 is a chip-processing potato with resistance to potato virus Y (PVY), late blight (*Phytophthora infestans*), tolerance to common scab (*Streptomyces scabies*), and demonstrated tolerance to *Verticillium* wilt. This variety has average yield with a high specific gravity, and a high percentage of A-size tubers with an attractive, uniform shape. MSX540-4 has a strong vine and a mid- to late-season maturity, and has demonstrated excellent long-term storage chip-processing quality. MSX540-4 has performed well in multiple locations in the PotatoesUSA National Chip Processing Trials (NCPT).

Incentives for production: Long-term chip-processing quality with resistance to PVY and late blight, and tolerance to common scab.

Morphological Characteristics:
Plant: Medium height vine, semi-erect with a balance between stems and foliage visible, and flowers.
Tubers: Round tubers with lightly netted, tan colored skin. Tubers have a creamy-white flesh with a low incidence of internal defects.

Agronomic Characteristics:
Vine Maturity: Mid- to late-season maturity.
Tubers: Smooth shaped tubers with lightly netted, tan colored skin and a creamy-white flesh.
Yield: Average yield under irrigated conditions, with uniform A-size tubers.
Specific Gravity: Averages similar to above Snowden in Michigan.
Culinary Quality: Chip-processes from short to long-term storage.
Diseases: Resistant to PVY and late blight (*Phytophthora infestans*), tolerant to common scab (*Streptomyces scabies*).

MSW485-2 (Huron Chipper)

Parentage: MSQ070-1 x MSR156-7
Developers: Michigan State University and the MSU AgBioResearch.
Plant Variety Protection: To Be Applied For.

Strengths: MSW485 is a chip-processing potato with resistance to and late blight (*Phytophthora infestans*), and stronger tolerance to common scab (*Streptomyces scabies*) than Atlantic. This variety has high yield and good specific gravity, with attractive, uniformly round tubers. MSW485-2 has a strong vine and a mid-season maturity, and has demonstrated excellent long-term storage chip-processing quality. MSW485-2 has performed well in multiple locations in the PotatoesUSA National Chip Processing Trials (NCPT) and national SFA (SNaC) trials.

Incentives for production: Excellent chip-processing quality out of the field and long-term chip quality with resistance to late blight and a good size profile.

Morphological Characteristics:
Plant: Medium height vine, semi-erect with a balance between stems and foliage visible, and flowers.
Tubers: Uniform, smooth, round tubers with lightly netted, tan colored skin. Tubers have a white flesh with a low incidence of internal defects.

Agronomic Characteristics:
Vine Maturity: Mid-season maturity.
Tubers: Smooth, round tubers with lightly netted, tan colored skin and a white flesh.
Yield: Above average yield under irrigated conditions, with uniform tubers.
Specific Gravity: Averages similar to above Atlantic and Snowden.
Culinary Quality: Chip-processes from short to long-term storage.
Diseases: Resistant to late blight (*Phytophthora infestans*) and tolerant to common scab (*Streptomyces scabies*).

MSX569-1R (Ilse Royale)

Parentage: MSS002-2R x MSS544-1R
Developers: Michigan State University and the MSU AgBioResearch.
Plant Variety Protection: To Be Applied For.

Strengths: MSX569-1R is a fresh market variety with an attractive red skin, bright white flesh, excellent round tuber shape, and tolerance to common scab (*Streptomyces scabies*). This variety has average yield with a high percentage of A-size tubers with an attractive, uniform shape. The bright red skin is highly desirable in the fresh market, and also maintains good red color in storage. This line has demonstrated good marketable yield potential in replicated trials at the MSU Montcalm Research Center, on grower field trials throughout Michigan, as well as in North Central Regional Trials, and trials in Florida and North Carolina. MSX569-1R has excellent internal quality (few defects) and a low incidence of blackspot bruise.

Incentives for production: Fresh market variety with a bright red skin, attractive tuber size and shape, excellent internal quality, and tolerance to common scab.

Morphological Characteristics*:*
Plant: Medium height vine, semi-erect with a balance between stems and foliage visible, and flowers.
Tubers: Round tubers with a smooth, bright red colored skin. Tubers have an attractive white flesh with a low incidence of internal defects.

Agronomic Characteristics*:*
Maturity: Mid-season maturity.
Tubers: Round tubers with a red skin and an attractive white flesh.
Yield: Average yield under irrigated conditions, similar or better than Red Norland.
Specific Gravity: Good fresh market specific gravity (1.055 in Michigan).
Culinary Quality: Excellent culinary quality.
Diseases: Tolerance to common scab (*Streptomyces scabies*).

II. Germplasm Enhancement

The trait mapping populations have been a major research focus for us over the previous four years as we try to correlate the field data with the genetic markers. We now have DNA SNP markers linked to late blight resistance, scab resistance, chip color, tuber asparagine and specific gravity. We will now start using this linkage information to assist us in breeding. Our first SNP marker is linked to a gene for late blight resistance on Chr. 9 and the second is located on Chr. 10 with new ones recently identified on Chr. 4 and Chr. 5. The ability to use the DNA markers to stack a set of late blight resistance genes will lead to durable late blight resistance.

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 are now placing more emphasis on the diploid breeding effort because of the advantages the breeding system brings when we introduce the ability to self-pollinate a line. Features of diploid breeding include 1) a simpler genetic system than current breeding methods, 2) tremendous genetic diversity for economic traits, 3) minimal crossing barriers to cultivated potato, 4) the ability to reduce genetic load (or poor combinations) through selfing and 5) the ability to create true breeding lines like wheat, soybeans and dry beans. We are also using some inbred lines of *S. chacoense* that have fertility and vigor (also a source of *Verticillium* wilt resistance to initiate our efforts to develop inbred lines with our own diploid germplasm. We have over 40 populations that we are cycling to make selections and we also selected diploid progeny from Atlantic, Superior, Manistee, MSZ219-14, Kalkaska, MSR127-2, MSS576-5SPL and others to cross to the self compatible material so we can develop inbred chip-processing diploid lines. This new diploid potato breeding project is expanding to develop promising lines to use as parents in the future as well as to think about F1 hybrid varieties like the breeders release with corn.

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 previous 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. With our new diploid breeding initiative we have developed a mapping population to link the beetle resistance with SNP markers. We will continue conducting field screening for resistance to Colorado potato beetle at the Montcalm Research Center. These lines are being used crosses to further transmit insect resistance.

III. Integration of Genetic Engineering with Potato Breeding

Regarding late blight resistance, we have many lines with the RB gene for late blight resistance transformed into MSU lines. The addition of the RB gene allows us to test the effect of multiple resistance genes on the strength of resistance. Our data supports the need to pyramid the late blight resistance R-genes to achieve the best levels of resistance. The RB gene is in Jacqueline Lee and MSL268-D. We now have generated some lines with 3-R-genes stacked with one transformation

We have also generated lines with the genes for water use efficiency (WUE). Field trials with reduced fertilizer and non-irrigated conditions were conducted for a subset of these lines from 2014 to 2017. The XERICO gene is showing the most promise. Lastly, we have generated and selected a Kalkaska invertase silencing line (Kal91.03) that has resistance to accumulating reducing sugars in 40F storage. We tested the agronomic characteristics of Kal91.03 in 2016 and 2017. The initial results are suggesting that the invertase silencing line has good tuber type, size and similar specific gravity. This suggests that we can correct sugar issues in a chip processing lines with this genetic engineering strategy. We will continue to evaluate in 2018.

Chipped directly after 3 months at 40F

Funding: Fed. Grant/MPIC/Potatoes USA

2017 POTATO VARIETY EVALUATIONS

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INTRODUCTION

Each year, the MSU potato breeding and genetics team conducts a series of variety trials to assess advanced potato selections from the Michigan State University and other potato breeding programs at the Montcalm Research Center (MRC). In 2017, we tested over 200 varieties and breeding lines in the replicated variety trials, plus over 150 lines in the National Chip Processing Trial (NCPT). The variety evaluation also includes disease testing in the scab nursery (Montcalm Research Center) and foliar late blight evaluation (Clarksville Research Center). The objectives of the evaluations are to identify superior varieties for fresh or chip-processing markets (chip, round white/yellow table, specialty/red and russet). 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 as well as from 45°F (7.2°C) and 50°F (10°C) storage at 3 and 6 months), along with susceptibilities to common scab, late blight (foliar and tuber), and blackspot bruising are determined.

We would like to acknowledge the collaborative effort of the Michigan Potato Industry and research colleagues Mathew Klein and the MSU Potato Breeding Team (especially N. Garrity, M. Alhashany, S. Islam, E. Pawa, F. Enciso, N. Kirkwyland, G. Billings and M. Forbush) for helping to get the field 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. Nutrient, weed, disease and insect management were similar to recommendations used by the commercial operations in Montcalm County. The field experiments were conducted on a sandy loam soil that has been out of potato production for 12 years. Oats were grown in 2016 on this ground.

The most advanced selections were tested in the Advanced chip and tablestock trials, representing selections at a stage after the preliminary trials. The other field trials were the North Central, Russet, Preliminary (chip-processors and tablestock), Preliminary Pigmented, the NCPT and the early observational trials.

2017 was the seventh 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 9 trial locations (Northern sites: NY, MI, WI, ND, OR and Southern: NC, FL, CA, TX) in addition to a scab trial in MN. For 2017, the scab trial was conducted in Wisconsin instead of Minnesota.

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, chip-processing, 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) for 2 minutes 15 seconds or until fully cooked. The chip color was measured visually with the SFA 1-5 color chart and a Hunter Colorimeter using crushed chips. 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 April. Select 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 Center. There has been very strong scab disease pressure at the new Montcalm Scab Disease Nursery for six years now. The 2017 late blight trial was 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 (from 50F tuber temperature) results for average spots per tuber have also been incorporated into the summary sheets.

RESULTS

A. Advanced Chip-Processing Trial (Table 1)

A summary of the 29 entries evaluated in the trial results is given in **Table 1**. Overall, the yields for the Advanced trial (136 days) were above average to above. The check varieties for this trial were Snowden, Atlantic, Pike and Lamoka. The highest yielding and most promising lines were MSZ222-19, MSV313-2, MSR127-2, MSZ052-11, MSW485-2 and MSZ219-1. Internal defects were minimal for 2017 except for Pike which had 40% internal brown spot in the large tubers. Specific gravity was high with a trial average of 1.086. Snowden and Atlantic had a specific gravity of 1.090 and 1.093, respectively. All chip-processing entries in the trial had excellent chip-processing quality out of the field, with an SFA score of 1.0. Many of the MSU breeding lines have good scab resistance. Sixteen MSU chipping lines were classified as having scab resistance scores better than Lamoka (see Table 1). Other promising lines in the trial were MSX540-4 (PVY and late blight resistant and scab tolerant), MSV030-4 (scab resistant), MSZ219-13, MSZ219-46 and MSZ219-14 (all three are scab, PVY and late blight resistant). MSX540-4 is being named Machinaw, and MSW485-2 is being named Huron Chipper.

B. North Central Regional Trial Entries (Table 2)

The North Central Trial is conducted in a wide range of environments (4 regional locations) to provide adaptability data for the release of new varieties from Michigan, Minnesota, North Dakota and Wisconsin. The trial was reformatted to focus on table potatoes. Twenty-seven entries were tested in Michigan in 2017. The results are presented in **Table 2**. The reference varieties for this trial were Red Norland, Yukon Gold and Russet Norkotah. The highest yielding line in the trial was MSY111-3. MSY111-3 produces a high percentage of oversize tubers that with no internal defects moderate scab tolerance. Other MSU lines that looked promising were MSW316-3PY, MSX324-1P (top appearance plus scab resistance), MSX569-1R and QSNDSU07-4RThere are some promising red-skinned and russet entries from North Dakota and Wisconsin. MSX569-1R is being named Ilse Royale.

C. Russet Trial (Table 3)

We continue to increase our russet breeding efforts to reflect the growing interest in russet types in Michigan. In 2017 19 lines were evaluated after 133 days. The results are summarized in **Table 3**. The Russet trial includes entries from the North Central Regional Trial (NCR). Russet Norkotah, GoldRush and Silverton Russet were the reference varieties used in the trial. In general, the yields were average for many russet lines while both references had below average yields. Specific gravity average for the trial was 1.081. There was not a high level of internal defects nor cull tubers. Bruise incidence was average. The highest yielding lines were A08433-4VRRUS, Silverton Russet, A07061-6RUS and AF5179-4RUS. Scab resistance was common among the lines but susceptibility was observed in a number of the russet lines (see Table 3). Late blight resistance was observed in Payette Russet at the CRC trial.

D. Adaptation Trial (Table 4)

The Adaptation Trial of the tablestock lines was harvested after 128 days and the results of 36 lines are summarized in **Table 4**. The many of the lines evaluated in the Adaptation Trial were tested in the Preliminary Trial the previous year. Four reference cultivars (Superior, Reba, Yukon Gold and Onaway) are reported in the tablestock trial. In general, the yields were above average and internal defects were low, but Elfe had 30% brown center incidence. The highest yielding lines were some European protected varieties. MSW125-1 is an attractive table selection high yield potential and scab tolerance. The challenge remains to combine scab and late blight resistance together. The lines with scab tolerance were MSX324-1P, MSW316-2PY, Oneida Gold from Wisconsin and some European varieties. Promising late blight tolerant lines were MSX324-1P and MSS576-5SPL.

E. Preliminary Trials (Tables 5, 6 and 7)

The Preliminary trials (chip, table, pigmented) are the first replicated trials 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. In 2017, there were 117 lines trialed in the three Preliminary trials.

The chip-processing Preliminary Trial (**Table 5**) had 59 entries was harvested after 126 days. Most lines chip-processed well from the field but specific gravity values were acceptable with Snowden at 1.091. Internal quality was predominantly vascular discoloration with other defects being more incidental for most lines. Promising MSU lines are MSZ025-2, MSX2225-2, MSX245-2y, MSZ022-16, and MSV507-007 combining yield, specific gravity, scab resistance and chip quality. We continue to make progress selecting for chip-processing with scab resistance with 32 lines in the trial with scab ratings equal or lower than 1.5. We are also combing chip-processing quality and late blight resistance, with 4 selections demonstrating strong foliar late blight resistance, and 3 lines with moderate late blight resistance.

Table 6 summarizes 27 tablestock entries evaluated in the Preliminary Tablestock Trial. Reba and Superior were the check varieties. This tablestock trial was harvested and evaluated after 121 days. MSZ615-2, MSZ590-1, MSZ622-1, MSV111-2 and MSX496-06 were the promising highest yielding lines. The first 4 lines mentioned combine high yield potential with scab resistance and good internal quality. MSX496-06 combines late blight resistance with good yield and tuber appearance. This trial also had a number of lines with higher levels of internal brown spot. The number of tablestock selections with scab resistance (16) and late blight resistance (8) continue to increase.

The interest in the specialty market continues to increase. In 2016 31 were evaluated in a targeted Preliminary Pigmented Trial (**Table 7**), which was harvested at 121 days. This trial evaluated breeding lines with unique skin and flesh colors. These lines have commercial agronomic performance and specialty characteristics, as well as some scab and late blight resistance. The most promising lines for yield were MSZ109-08PP, MSZ109-10PP, MSZ443-01PP and MSZ428-1PP. The purple-fleshed lines are noted for their intense dark flesh color combined with round tuber shape and bright skins. Scab resistance was noted in 18 of the entries. Also, only 4 lines had foliar tolerance to late blight in the CRC late blight trials.

F. Potato Common Scab Evaluation (Tables 8 and 9)

Each year, a replicated field trial is conducted to assess resistance to common scab. The scab trial is now located at the Montcalm Research Center where high common scab disease pressure was observed in the previous six years. This location is being used for the early generation observational scab trial (379 lines) and the scab variety trial (256 lines).

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 2014-2016 scab ratings are based upon the Montcalm Research Center site. **Table 8** categorizes many of the varieties and advanced selections tested in 2017 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 – 1.5) correlates with <10% infection. Scores of 4.0 or greater are found on lines with >50% surface infection and severe pitted lesions.

The check varieties Russet Norkotah, GoldRush, Red Norland, Yukon Gold, Onaway, Pike, Atlantic, and Snowden can be used as references (bolded in **Table 8**). The table is sorted in ascending order by 2017 scab rating. This year's results continue to indicate that we have been able to breed numerous lines with resistance to scab. Scab ratings ranged from 0.5 -3.8 for the variety trial. A total of 118 lines, of the 256 tested, had a scab rating of 1.5 or lower in 2017. Most notable scab resistant MSU lines are found in the trial summaries **(Tables 1-7)**.

There are also an increasing number of scab resistant lines that also have late blight resistance and PVY resistance such as Saginaw Chipper (MSR061-1), MSX540-4, MSZ219-1, MSZ219-13 and MSZ219-14. 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, 220 had scab resistance (scab rating of ≤ 1.5) (**Table 9**). The early generation selections also include diploid selections.

H. Late Blight Trial (Tables 10 and 11)

In 2017, the late blight trial was planted at the Clarksville Research Center. 317entries were planted in early June for late blight evaluation. These include lines tested in a replicated manner from the agronomic variety trial (189 lines) and 128 entries in the early generation observation plots. The trials were inoculated in late July and August with the US-23 genotype of *P. infestans*. Late blight infection was identified in the plots about one month after the first inoculation due to the hot dry weather. The plots were evaluated 1-2 times per week over a 6-week period following inoculation. In 2017 the replicated variety trial 31 lines had late blight resistance, while 35 lines in the early generation observation plots had 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, Tollocan, B0718-3, Chaposa, *S. bulbocastanum*, *S. microdontum*, Muruta, Enfula, Perkoz, Basadre, etc.). Most notable lines with late blight resistance include Payette Russet, MSX540-4, MSZ219-01, MSZ219-13, MSZ219-14, MSX497-06, MSW485-2, MSW121-2R and MSV235-2PY.

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 12**. 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 2017 the bruise levels were average compared to previous years. There are many lines with lower blackspot bruise potential across the trials. Some of our advanced selections are similar to or less than Atlantic and Snowden in their level of bruising. A few lines will high susceptibility to bruise were identified and will be discontinued from testing. All the bruise ratings are also found in the variety trial tables (**Tables 1-7**).

J. National Chip Processing Trial (NCPT) data available on-line

The Potatoes USA-funded National Chip Processing Trial (NCPT) is an effort to synergize the strengths of the public breeding programs in the U.S. to identify improved chip-processing varieties for the industry. Cooperating breeding programs include the USDA (Idaho and Maryland) and land grant universities (Colorado, Maine, Michigan, Minnesota, North Carolina, North Dakota, New York, Oregon, Wisconsin and Texas). The coordinated breeding effort includes early stage evaluation of key traits (yield, specific gravity, chip color, chip defects and shape) from coordinated trials in 11 locations. Since the inception of the trial in 2010, over 800 different potato entries, including reference varieties, have been evaluated. The data for all the lines tested are summarized on a searchable, centralized database housed at Medius Ag. More than 40 promising new breeding lines from the trials have been fast-tracked for larger-scale commercial trials and processor evaluation. The NCPT is also a feeder for the national SNaC International trials. The data from all trials are available in a searchable, on-line database (https://potatoesusa.mediusag.com). We are using the NCPT trials to more effectively identify promising new selections. These are MSV301-2, MSV358-3, MSW485-2, MSW509-5 and MSX540-4. MSZ219-1, MSZ219-14 and MSW075-1 have been added to the mini-fast track. Minituber production and/or commercial seed have been produced of these lines and will be tested in Michigan in 2018.

ADVANCED CHIP-PROCESSING TRIAL
MONTCALM RESEARCH CENTER
May 9 to September 22, 2017 (136 days)
DD Base 40°F 2935[9]

		CWT/A		PERCENT OF TOTAL[1]								PERCENT (%) TUBER QUALITY[4]							LB[8] RAUDPC	3-YR AVG US#1
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[2]	OTF SED[3]	HH	VD	IBS	BC	SCAB[5]	MAT[6]	BRUISE[7]	x100	CWT/A
MSX150-1	4	573	602	95	4	76	19	1	1.082	1.0	0.0	0	18	3	0	2.3	3.8	3.0	-	-
MSZ222-19	3	562	600	94	4	79	15	2	1.083	1.0	0.0	7	3	0	7	0.8	3.8	1.5	-	524*
MSV313-02	4	523	534	98	2	36	62	1	1.084	1.0	1.0	5	5	0	0	1.0	3.8	1.4	-	423
MSR127-2	4	516	547	94	5	83	11	0	1.086	1.0	0.0	0	10	0	0	1.0	3.5	2.3	-	451
MSZ052-11	4	515	557	93	6	80	12	1	1.080	1.0	0.0	0	15	0	0	0.8	3.3	1.7	-	-
MSW485-2	4	492	563	87	12	84	3	1	1.090	1.0	3.0	30	5	0	13	1.8	3.5	0.9	16.3	444*
MSZ219-01	4	457	477	96	4	85	11	1	1.084	1.0	0.0	5	13	0	0	1.0	3.0	1.2	9.7	457*
Snowden	**4**	**442**	**479**	**92**	**8**	**88**	**4**	**0**	**1.090**	**1.0**	**1.0**	**0**	**33**	**0**	**0**	**2.5**	**2.0**	**2.6**	**19.6**	**432**
Atlantic	**4**	**439**	**465**	**94**	**4**	**70**	**24**	**1**	**1.093**	**1.0**	**1.0**	**18**	**3**	**0**	**10**	**2.5**	**2.8**	**1.4**	**24.3**	**400**
MSX542-2	4	410	451	91	8	69	22	1	1.083	1.0	1.0	3	3	0	3	2.0	4.0	0.2	24.0	-
MSZ219-46	3	408	436	94	5	83	11	1	1.080	1.0	1.0	0	3	0	0	1.0	3.5	1.1	6.7	-
Manistee	4	403	431	93	6	81	12	0	1.084	1.0	0.0	0	3	8	3	2.3	2.3	0.9	-	312
MSZ242-09	4	402	448	90	8	78	11	2	1.094	1.0	0.0	0	10	5	0	1.7	3.8	1.1	26	413*
MSZ219-13	4	397	424	94	6	85	8	1	1.078	-	-	3	3	0	0	0.5	4.0	1.6	2.9	-
W8822-1	4	397	442	90	8	78	12	2	1.090	1.0	0.0	0	8	0	0	0.7	3.8	1.5	24.8	-
AF4138-8	2	395	445	89	11	81	8	0	1.066	1.0	0.0	0	20	5	5	1.5	2.5	0.5	30.0	-
MSV033-01	4	380	423	90	8	61	29	2	1.086	1.0	0.0	0	20	0	0	2.3	4.0	2.0	-	371*
MSV358-3	4	377	416	90	10	83	8	0	1.078	1.0	0.0	3	8	3	0	1.5	2.8	0.9	-	345
MSZ219-14	4	375	392	96	3	74	22	1	1.084	1.0	0.0	20	8	0	3	0.7	3.5	1.1	9.8	395*
MSW075-01	4	368	419	87	13	83	4	0	1.080	1.0	0.0	0	20	0	0	1.2	3.3	1.0	34.1	-
Lamoka	**4**	**368**	**397**	**93**	**7**	**82**	**11**	**1**	**1.086**	**1.0**	**0.0**	**0**	**5**	**0**	**0**	**1.7**	**2.8**	**1.2**	**29.0**	**341**
MSV030-04	4	361	410	88	11	82	6	1	1.092	1.0	0.0	0	8	0	0	2.0	4.0	1.5	-	344
Pike	**2**	**342**	**360**	**95**	**5**	**71**	**24**	**0**	**1.091**	**1.0**	**0.0**	**0**	**10**	**40**	**0**	**0.7**	**3.5**	**1.5**	**19.9**	**309***
MSW064-1	4	338	368	92	8	85	7	0	1.085	1.0	3.0	3	25	0	0	1.3	4.0	0.8	21.6	-
MSV331-3	4	324	362	89	11	83	6	0	1.076	1.0	2.0	0	0	0	0	0.8	4.0	2.4	41.6	-
MSZ242-07	4	295	359	82	15	74	8	3	1.097	1.0	1.0	3	0	0	0	1.3	4.0	0.6	-	-
MSV380-1	3	285	314	91	8	87	4	1	1.085	1.0	0.0	0	3	0	0	0.7	2.8	0.7	-	271
MSX540-4	4	276	313	88	12	84	4	0	1.093	1.0	1.0	0	18	0	0	2.2	3.5	1.7	11.8	335
MSZ242-13	4	245	285	86	13	82	4	1	1.098	1.0	0.0	0	0	0	0	1.5	4.0	1.0	-	243*
MEAN		402	439						1.086							1.4	3.4	1.4	-	366
$HSD_{0.05}$		166	167						0.010							2.0			29.0	

* Two-Year Average

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.
[2]CHIP SCORE: SNAC Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
[3]SED: Stem End Defect, Based on Paul Bethke's (USDA/UWisconsin - Madison) 0 - 5 scale. 0 = no SED; 3 = significant SED; 5 = severe SED
[4]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.
[5]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[6]MATURITY RATING: August 29, 2017; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).
[7]BRUISE: Simulated blackspot bruise test, average number of spots per tuber.

Plant Date: 5/9/17
Vine Kill: 8/31/17
Days from planting to vine kill: 114

[9]Enviroweather: Entrican Station. Planting to vine kill

Table 2

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH CENTER
May 09 to September 14, 2017 (128 days)
DD Base 40°F 2935[7]

LINE	N	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	PERCENT (%) TUBER QUALITY[2] HH	VD	IBS	BC	SCAB[3]	MAT[4]	Bruise[5]	LB[6] RAUDPC x100	3-YR AVG US#1 CWT/A
Yellow Flesh and Pigmented																		
W13100-5Y	2	428	465	92	3	85	7	5	1.083	0	5	0	0	1.8	4.0	0.6	22.4	-
MSN230-1RY	2	426	493	85	12	79	6	3	1.083	0	10	0	0	1.2	4.0	0.8	-	-
ND1243-1PY	2	359	434	82	17	81	1	1	1.079	0	0	0	0	2.7	3.5	1.4	-	-
Yukon Gold	**2**	**351**	**379**	**93**	**6**	**83**	**10**	**2**	**1.080**	**0**	**10**	**5**	**0**	**2.2**	**1.5**	**0.6**	**31**	**374**
W13103-2Y	2	348	399	87	13	81	6	0	1.060	0	0	0	0	1.2	1.5	0.1	26	-
ND113207-1R	2	326	407	79	21	76	3	0	1.062	0	0	0	0	2.0	2.0	0.4	-	-
QSNDSU07-04R	2	297	358	83	15	81	2	2	1.066	0	0	0	0	1.3	2.0	0.4	27	-
ND1241-1Y	2	288	362	79	20	79	0	1	1.091	0	0	0	0	3.2	2.5	0.9	-	-
Red Norland	**2**	**263**	**293**	**89**	**9**	**89**	**0**	**2**	**1.063**	**0**	**15**	**0**	**0**	**1.5**	**1.0**	**0.2**	**44.6**	**332**
MSW316-3PY	2	241	287	84	7	80	4	9	1.072	0	5	0	0	1.7	3.0	0.6	33.3	310*
MST075-1R	2	234	259	89	8	75	14	3	1.074	0	0	0	0	1.7	3.0	0.8	-	-
AND00272-1R	2	223	356	62	32	62	0	6	1.063	0	0	0	0	ND	1.5	0.6	-	-
W10209-2R	2	222	285	77	22	77	0	1	1.071	0	0	0	0	1.5	1.5	0.5	25.8	295
ATND99331-2PintoY	2	214	255	83	13	72	11	4	1.069	0	5	0	0	2.2	3.5	0.4	-	271*
MSX569-1R	2	213	259	83	14	80	3	3	1.058	0	15	5	0	1.5	1.0	0.1	47	-
MSX324-1P	2	213	256	83	14	82	1	3	1.081	0	0	0	0	0.8	1.5	1.0	26	238
ND1232B-2RY	2	211	353	58	42	58	0	0	1.071	0	10	0	0	ND	2.0	0.8	-	-
MSV434-01Y	2	150	178	84	15	84	0	1	1.073	0	0	0	0	1.6	2.5	0.4	-	-
Russet																		
W13030-3rus	2	459	559	82	12	79	3	6	1.090	0	5	0	0	2.5	3.0	2.7	19.5	-
W13008-1rus	2	424	472	89	9	74	15	2	1.072	0	0	0	0	1.2	2.5	0.5	39.5	-
W13014-5rus	2	305	360	82	11	75	7	7	1.094	0	5	10	0	1.3	4.0	1.9	10	-
W13027-32rus	2	241	366	67	11	53	14	22	1.071	0	5	0	0	2.3	3.5	1.2	26	-
W9523-1rus	2	224	278	80	18	77	4	2	1.075	0	10	0	0	1.3	2.0	1.8	29	277*
Russet Norkotah	**2**	**205**	**271**	**76**	**22**	**76**	**0**	**2**	**1.068**	**0**	**10**	**0**	**0**	**1.9**	**2.0**	**0.7**	**28.1**	272*
W13006-2rus	2	199	301	60	34	60	0	5	1.087	0	10	0	0	2.3	2.5	1.5	35.8	-
Round White																		
MSY111-01	2	545	576	95	4	68	27	1	1.077	0	10	0	0	1.7	3.5	1.1	19	-
MSU161-01	2	234	256	91	6	77	14	3	1.075	0	5	0	0	2.2	3.5	0.9	12.2	-
MEAN		290.5	352.4						1.074					1.8	2.5	0.8	-	310
$HSD_{0.05}$									0.011					2.0			29.0	

* Two-Year Average

[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 29, 2017; 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.
[6]LB RAUDPC: Late blight (*P. infestans* US-23) foliar disease reaction.

Plant Date:	5/9/17
Vine Kill:	8/31/17
Days from planting to vine kill:	114

[7]Enviroweather: Entrican Station. Planting to vine kill

RUSSET TRIAL
MONTCALM RESEARCH CENTER
May 09 to September 19, 2017 (133 days)
DD Base 40°F 2935[7]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							LB[6] RAUDPC	3-YR AVG US#1
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	x100	CWT/A
A08433-4VRRUS	4	526	632	83	14	81	2	3	1.086	0	5	0	0	2.2	4.0	1.6	17.8	-
Silverton Russet	**4**	**510**	**572**	**89**	**7**	**74**	**15**	**4**	**1.078**	**5**	**3**	**2.5**	**5**	**0.8**	**4.0**	**1.2**	**13.8**	**365**
A07061-6Rus	4	483	620	78	20	77	1	2	1.084	0	5	0	0	2.7	4.0	1.8	34.9	-
AF5179-4Rus	4	455	527	86	10	76	10	4	1.094	3	3	0	0	3.8	4.0	3.1	19.7	-
Russet Norkotah	**4**	**435**	**498**	**87**	**9**	**76**	**11**	**3**	**1.077**	**3**	**10**	**0**	**0**	**1.9**	**2.3**	**1.3**	**28.1**	**313**
CW08221-5Rus	4	407	487	84	13	77	7	3	1.066	0	8	0	0	1.2	2.3	2.3	23.3	-
Goldrush	**4**	**402**	**496**	**81**	**11**	**73**	**9**	**8**	**1.076**	**0**	**3**	**0**	**0**	**1.5**	**2.5**	**0.8**	**45.8**	**-**
WND8625-2Rus	4	389	430	90	7	72	19	2	1.082	25	0	3	0	2.7	3.8	1.2	42.4	-
ATX91137-1Rus (Reveille Russet)	4	387	457	84	10	72	12	7	1.077	0	0	2.5	0	1.7	3.5	1.0	35.0	389
WAF10073-3Rus	4	376	496	76	18	72	4	6	1.073	0	0	0	0	1.0	2.3	2.7	35.8	-
AF5091-8Rus	4	369	453	81	7	63	18	12	1.072	0	3	5	2.5	2.5	2.0	1.3	28.3	374*
AF5312-1Rus	4	351	424	77	19	75	2	4	1.079	0	3	0	0	1.0	2.8	2.3	30.8	-
ND050032-4Rus	3	347	442	79	13	71	8	8	1.081	0	0	0	0	1.2	3.5	1.3	24.0	376*
W9742-3Rus	4	334	405	82	12	80	3	6	1.102	0	0	0	0	1.8	3.5	0.7	14.6	284
CO8155-2RU/Y	2	264	376	71	25	71	0	4	1.080	0	0	0	0	2.5	2.5	1.6	14.4	-
A02507-2LB (Payette Russet)	4	263	337	78	16	74	4	6	1.092	0	3	0	0	1.2	4.0	2.3	0.2	-
A06021-1TRus	4	238	324	71	23	68	4	5	1.083	3	8	0	3	1.5	2.0	1.2	44.6	-
A06030-23Rus	4	203	292	70	21	68	3	8	1.087	0	5	0	0	1.5	2.0	2.9	40.0	-
TX08352-5Rus	4	140	252	54	44	54	0	2	1.067	0	0	0	0	1.3	1.8	1.7	46.6	241*
MEAN		362	448						1.081					1.8	3.0	1.7	-	338
$HSD_{0.05}$		183	178						0.010					2.0			29.0	

* Two-Year Average

[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 29, 2017; 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.
[6]LB RAUDPC: Late blight (*P. infestans* US-23) foliar disease reaction.

Plant Date: 5/9/17
Vine Kill: 8/31/17
Days from planting to vine kill: 114

[7]Enviroweather: Entrican Station. Planting to vine kill

Table 4

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH CENTER
May 09 to September 14, 2017 (128 days)
DD Base 40°F 2935[7]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							LB[6] RAUDPC
LINE		US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	x100
Jelly	2	555	590	94	2	76	18	4	1.082	0	0	10	0	2.2	3.5	0.4	-
Cerrata	2	540	581	93	5	85	8	2	1.074	0	0	0	0	1.8	3.5	0.2	14.8
Musica	2	504	604	84	12	78	6	4	1.077	0	25	0	0	1.8	3.0	1.0	6.7
MSW125-1	4	468	514	89	6	81	8	5	1.079	0	18	0	0	0.8	3.8	0.4	18.4
Melou	2	466	564	83	15	83	0	2	1.063	0	30	0	0	2.2	2.0	0.2	-
W9576-11Y	2	451	495	91	8	88	3	1	1.062	0	10	0	0	1.3	1.0	0.1	45.8
MSW125-3	4	427	456	94	6	86	7	1	1.061	0	15	8	0	1.7	1.5	0.3	24.2
Julinka	2	409	505	81	16	80	1	3	1.070	0	15	0	0	1.8	2.0	0.3	24.1
Allora	2	408	454	90	6	79	11	4	1.072	0	15	0	0	2.2	2.5	0.8	29.0
Onaway	2	406	447	91	4	75	15	5	1.070	0	20	0	0	2.0	1.5	0.8	39.1
MSV301-02	4	402	431	93	6	90	3	1	1.086	0	3	0	5	1.3	2.5	0.4	-
Superior	3	394	416	95	4	89	6	2	1.077	0	13	3	0	1.2	1.3	0.5	33.8
Reba	2	394	426	92	6	81	12	2	1.076	0	5	0	0	2.2	2.5	0.5	39.3
NY149	2	390	453	86	13	85	1	1	1.081	0	5	0	0	1.8	2.5	0.2	30.8
NY161	2	379	447	85	15	85	0	0	1.075	0	5	0	5	1.7	2.0	0.4	32.4
Elfe	2	359	418	86	10	78	8	3	1.064	0	10	5	30	2.7	1.0	0.1	-
Montreal	2	357	436	81	11	74	7	8	1.070	0	15	5	0	2.3	2.5	2.0	29.5
Yukon Gold	**3**	**353**	**372**	**95**	**4**	**84**	**10**	**1**	**1.083**	**0**	**3**	**0**	**0**	**2.2**	**1.0**	**0.5**	**30.8**
Madison	2	348	378	92	7	86	6	1	1.101	20	10	0	0	2.0	1.5	1.1	-
Oneida Gold	2	348	381	91	7	88	3	1	1.081	0	5	10	0	1.3	3.0	1.1	15.5
Viviana	2	345	399	86	13	86	1	1	1.065	0	30	0	0	2.8	1.0	1.6	40.8
MSU161-1	4	345	395	87	10	84	3	3	1.075	0	8	3	3	2.2	3.0	0.9	12.2
Wega	2	340	467	73	26	70	2	1	1.059	5	20	10	0	1.5	2.0	0.2	23.3
NY157	2	339	393	86	13	82	4	0	1.084	0	5	0	0	2.2	2.5	1.2	22.2
Alegria	2	336	387	87	9	86	1	4	1.080	0	20	0	0	2.0	2.5	0.3	28.3
NDAF102629C-4	2	318	360	89	10	85	4	1	1.071	0	10	0	0	1.7	1.5	0.1	29.1
Wendy	2	316	493	64	34	63	1	2	1.064	0	10	0	0	2.8	2.5	0.5	24.9
MSW316-3PY	4	294	390	72	19	72	0	9	1.077	0	10	0	0	1.7	4.0	0.5	33.3
MSS576-5SPL	4	294	316	93	6	80	12	2	1.077	0	5	0	3	1.8	3.0	0.6	14.7
MST075-1R	4	292	343	83	10	78	5	7	1.074	0	3	0	0	1.7	3.0	0.4	-
MSU383-A	4	265	298	85	13	80	5	2	1.063	0	15	3	0	1.3	1.8	0.2	-
MSW148-1P	4	240	366	66	31	66	0	3	1.086	0	0	0	0	2.3	3.0	0.9	-
MSX324-1P	4	207	258	79	18	78	1	2	1.085	0	0	3	0	0.8	1.3	1.1	25.8
Ciklaman	2	147	330	45	52	45	0	3	1.092	0	5	0	0	2.5	2.0	0.8	3.2
MSX569-1R	4	111	141	79	17	76	4	3	1.059	0	30	8	0	1.5	1.3	0.3	47.0
Lollipop	2	58	219	24	75	24	0	0	1.070	0	0	0	0	0.7	2.5	0.8	35.8
MEAN		350	414						1.075					1.8	2.2	0.6	-
$HSD_{0.05}$		189	228						0.010					2.0			29.0

[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 29, 2017; 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.
[6]LB RAUDPC: Late blight (*P. infestans* US-23) foliar disease reaction.

Plant Date:	5/9/17
Vine Kill:	8/31/17
Days from planting to vine kill:	114

[7]Enviroweather: Entrican Station. Planting to vine kill

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH CENTER
May 9 to September 12, 2017 (126 days)
DD Base 40°F 2935[9]

		CWT/A		PERCENT OF TOTAL[1]								PERCENT (%) TUBER QUALITY[4]							LB[8] RAUDPC
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[2]	OTF SED[3]	HH	VD	IBS	BC	SCAB[5]	MAT[6]	BRUISE[7]	x100
MSV498-1	2	591	613	96	4	74	22	0	1.076	1.0	1.0	10	10	0	0	1.2	3.0	1.2	-
MSZ219-44	1	571	624	92	8	82	10	1	1.077	1.0	2.0	0	0	0	0	1.2	4.0	0.7	7.1
MSZ269-1Y	2	565	601	94	6	84	10	0	1.083	1.0	2.0	0	0	5	0	2.0	4.0	4.1	25.5
MSY111-1	2	560	580	97	3	72	24	0	1.074	1.0	1.0	0	5	0	0	1.3	3.5	1.4	18.7
MSZ102-5	1	541	582	93	5	80	13	2	1.079	1.0	0.0	0	10	0	0	1.3	4.0	1.4	-
MSV502-05	2	501	545	92	8	86	6	0	1.079	1.0	1.0	0	0	0	0	1.7	3.5	0.8	-
MSZ025-2	2	501	532	94	6	82	12	0	1.084	1.0	1.0	0	5	0	0	2.2	3.0	1.4	24.9
MSZ118-05	1	498	523	95	4	90	6	1	1.078	1.0	1.0	0	10	0	0	1.0	4.0	0.8	-
MSX225-2	1	495	539	92	7	75	16	1	1.085	1.0	1.0	0	10	10	0	1.2	4.0	2.3	-
MSX245-2Y	2	491	515	95	5	77	18	0	1.082	1.0	1.0	0	5	10	0	1.5	4.0	1.1	-
MSZ022-16	2	486	536	91	9	87	4	0	1.089	1.0	2.0	0	10	0	0	1.3	4.0	-	-
MSV127-2	2	485	514	94	6	72	22	0	1.086	1.0	1.0	0	15	10	25	2.2	3.5	2.3	31.5
MSX111-3	2	485	508	96	4	70	26	0	1.091	1.0	1.0	5	0	0	5	2.5	4.0	2.5	-
MSV507-007	2	471	494	95	4	79	16	1	1.084	1.0	2.0	0	10	0	0	2.0	3.5	2.5	-
MSZ118-08	2	470	485	97	3	72	26	0	1.078	1.0	2.0	0	15	0	0	1.3	4.0	1.2	-
MSY089-2	2	466	482	97	3	65	31	0	1.082	1.0	1.0	0	10	0	0	1.8	3.5	1.3	21.6
MSY156-02	2	466	513	91	9	81	10	0	1.083	1.0	1.0	0	0	5	0	1.3	3.5	1.3	-
MSZ091-3	2	461	482	96	4	68	28	0	1.080	1.0	1.0	0	5	0	0	2.2	4.0	1.6	15.1
W9968-5	2	454	517	88	7	75	12	5	1.092	1.0	1.0	0	30	0	0	2.0	4.0	1.5	26.3
MSZ052-02	2	452	487	93	7	86	7	0	1.082	1.0	1.0	0	10	0	0	1.5	2.5	1.7	-
MSY071-1	2	440	484	91	6	76	15	3	1.080	1.0	1.0	20	0	0	0	2.5	4.0	1.7	11.1
NY162	2	423	445	95	5	81	14	0	1.094	1.0	0.0	0	0	0	0	1.3	3.5	3.8	34.1
Snowden	**2**	**415**	**460**	**90**	**10**	**81**	**9**	**0**	**1.091**	**1.0**	**1.0**	**0**	**20**	**0**	**0**	**2.5**	**3.5**	**3.1**	**19.6**
MSY256-A	2	395	424	93	6	81	12	1	1.087	1.0	1.0	0	0	0	10	1.7	3.0	3.4	-
MSZ022-19	2	395	410	96	4	83	14	0	1.082	1.0	1.0	0	0	0	0	1.8	4.0	1.0	-
MSX189-3	2	391	406	97	3	70	26	0	1.077			0	0	10	0	2.0	4.0	1.1	31.5
MSV507-073	2	384	428	90	10	85	5	0	1.094	1.0	1.0	0	5	0	0	1.7	3.0	3.2	-
MST458-4	2	382	409	94	4	78	16	2	1.082	1.0	0.0	0	0	0	0	1.8	3.0	1.3	38.1
MSX345-6Y	2	380	395	96	4	85	11	0	1.088	1.0	1.0	0	0	0	0	1.8	3.5	1.6	-
MSZ063-02	2	377	429	88	12	82	6	0	1.089	1.0	2.0	0	10	0	0	1.5	3.5	0.8	27.4
MSZ022-07	2	368	419	88	9	70	17	4	1.082	1.0	0.0	0	5	0	0	1.0	3.0	2.1	-
MSX209-1	2	366	414	87	7	73	14	6	1.074	1.0	0.0	0	0	0	0	1.7	2.0	2.0	-
MSZ251-01	2	364	403	90	10	84	6	0	1.093	1.0	0.0	0	0	0	5	1.3	2.5	2.2	28.2
MSZ248-10	2	361	407	86	13	78	8	1	1.081	1.0	0.0	0	20	0	0	1.2	4.0	2.2	25.2
MSZ052-31	2	360	392	92	2	80	12	6	1.076	1.0	2.0	10	5	0	5	-	3.0	0.8	-
MSX501-5	2	341	397	86	11	77	9	3	1.083			0	5	0	0	1.8	3.5	0.8	24.8
MSY077-5	2	336	374	90	10	78	12	0	1.080	1.0	1.0	10	10	0	0	2.2	4.0	1.2	13.0
MSZ282-6	2	335	380	88	12	82	5	0	1.086	1.0	0.0	0	0	0	0	0.8	3.0	0.9	40.8
MSX120-5Y	2	328	365	90	10	81	9	0	1.080	1.0	2.0	0	15	0	0	1.8	4.0	1.6	-
MSY027-2	2	320	348	92	7	83	9	1	1.079	1.0	2.0	0	0	0	0	0.8	3.5	1.2	-

Table 5

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH CENTER
May 9 to September 12, 2017 (126 days)
DD Base 40°F 2935[9]

												PERCENT (%)							LB[8]
		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	TUBER QUALITY[4]							RAUDPC
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	MAT[6]	BRUISE[7]	x100
MSZ246-1	2	320	368	87	13	84	3	0	1.086	1.0	1.0	0	0	0	0	1.3	2.5	1.6	-
MST424-6	2	319	357	89	10	87	2	1	1.080	1.0	0.0	0	0	0	0	1.3	3.0	1.3	-
MSY012-2	2	319	391	82	18	82	0	0	1.078			0	0	0	0	1.3	2.0	0.5	29.0
MSV427-1	2	297	319	92	8	75	17	0	1.076	1.0	0.0	0	5	10	0	0.8	3.5	0.9	25.6
MSX526-2Y	2	295	360	82	18	79	3	0	1.075	1.5	2.0	0	0	0	0	2.2	2.0	0.9	20.8
MSW168-2	2	294	331	89	11	83	6	0	1.086	1.0	1.0	0	10	0	0	1.2	3.5	1.4	15.9
MSY046-3	2	292	362	81	19	78	2	0	1.068	1.0	2.0	0	10	0	0	0.7	2.0	0.4	28.3
MST306-1	2	290	368	79	20	79	0	2	1.089	1.0	1.0	0	0	0	0	1.8	3.0	1.7	30.3
MSZ042-07	2	289	340	85	14	82	3	2	1.099	1.0	0.0	0	0	0	0	1.5	4.0	1.2	18.1
MSX417-01	2	278	325	86	12	83	2	2	1.086	1.0	1.0	0	5	0	0	1.5	2.0	1.6	-
MSW464-3	2	277	303	91	9	86	5	0	1.089	1.0	0.0	0	10	0	0	2.0	3.0	0.9	1.6
MSW299-2	2	270	320	75	22	72	3	4	1.082	1.0	1.0	0	0	0	0	1.7	3.5	0.8	14.9
MSX245-1	2	269	342	79	21	77	2	0	1.080	1.0	0.0	0	0	0	0	2.2	2.0	0.5	-
MSX526-01	2	265	331	80	9	67	12	11	1.081	1.0	0.0	0	5	0	15	1.3	3.0	1.5	19.5
MSV507-012	2	254	277	92	8	72	19	0	1.086	1.0	1.0	10	5	0	0	1.2	4.0	2.8	-
MSX420-04Y	2	244	312	78	22	76	2	0	1.078	1.0	0.0	0	0	0	0	1.3	3.0	1.2	-
MSX177-07Y	2	223	295	74	17	68	6	9	1.082	1.0	0.0	0	20	0	0	1.2	3.5	1.0	-
MSZ052-53	1	159	200	80	20	60	20	0	1.082	1.0	1.0	0	0	0	0	0.8	2.0	0.8	-
MEAN		387	427						1.083							1.6	3.3	1.5	-
$HSD_{0.05}$		311	281						0.014							2.0			29.0

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.
[2]CHIP SCORE: SNAC Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
[3]SED: Stem End Defect, Based on Paul Bethke's (USDA/UWisconsin - Madison) 0 - 5 scale. 0 = no SED; 3 = significant SED; 5 = severe SED
[4]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.
[5]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[6]MATURITY RATING: August 29, 2017; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).
[7]BRUISE: Simulated blackspot bruise test average number of spots per tuber.
[8]LB RAUDPC: Late blight (*P. infestans* US-23) foliar disease reaction.

Plant Date:	5/9/17
Vine Kill:	8/31/17
Days from planting to vine kill:	114

[9]Enviroweather: Entrican Station. Planting to vine kill

Table 6

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH CENTER
May 9 to September 7, 2017 (121 days)
DD Base 40°F 2935[7]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]							LB[6] RAUDPC
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	BRUISE[5]	x100
Soraya	2	688	793	87	4	80	6	9	1.068	5	0	0.0	0.0	2.0	3.0	0.4	22.1
MSW154-4	2	517	529	98	2	56	42	0	1.075	0	0	20.0	0.0	2.2	3.5	1.5	15.9
MSZ615-2	2	488	502	97	3	72	25	0	1.072	0	0	0.0	5.0	1.2	2.5	0.9	44.5
MSZ590-1	2	486	500	97	3	79	18	0	1.065	10	0	0.0	0.0	1.3	3.0	0.8	-
MST148-3	2	481	505	95	4	82	13	1	1.080	5	0	0.0	0.0	2.5	4.0	1.5	3.7
MSZ562-4	2	471	527	87	10	71	16	3	1.069	0	10	5.0	0.0	2.7	4.0	0.9	2.8
QSMSU10-09	2	468	505	93	6	77	16	1	1.078	0	0	0.0	0.0	1.2	3.0	1.2	33.3
Superior	**2**	**465**	**474**	**98**	**2**	**85**	**13**	**0**	**1.077**	**0**	**5**	**10.0**	**0.0**	**1.2**	**1.5**	**1.2**	**33.8**
MSZ622-1	2	448	489	91	9	81	10	0	1.062	0	0	0.0	0.0	0.8	3.0	0.6	39.5
MSV111-2	2	431	514	84	16	82	2	1	1.084	0	15	15.0	0.0	1.7	4.0	0.8	22.0
MSZ513-2	2	426	445	96	4	71	25	0	1.073	0	0	15.0	0.0	1.5	3.0	0.8	28.1
MSZ004-1	2	425	441	96	3	73	23	1	1.071	15	0	25.0	10.0	2.3	3.0	1.0	28.7
Reba	**2**	**424**	**449**	**94**	**6**	**83**	**12**	**0**	**1.072**	**0**	**0**	**5.0**	**0.0**	**2.2**	**3.0**	**0.8**	**39.3**
MSX497-06	1	423	447	95	5	66	29	0	1.074	0	20	0.0	0.0	2.5	3.0	1.5	7.6
MSX497-02	1	419	432	97	3	79	18	0	1.073	10	0	0.0	0.0	1.8	3.0	0.8	5.1
MSZ407-2Y	2	419	437	96	4	71	24	0	1.084	0	0	0.0	0.0	1.2	3.0	1.5	30.8
MSW128-2	1	412	454	91	9	82	9	0	1.062	0	0	0.0	0.0	1.8	3.0	0.6	8.9
MSZ210-8	2	410	485	85	15	82	3	0	1.072	0	5	0.0	0.0	2.5	3.5	0.8	23.0
MSY507-02	2	391	451	87	8	85	2	6	1.083	0	25	0.0	0.0	1.3	3.0	1.4	22.6
MSW092-1	1	378	517	73	25	73	0	2	1.076	0	0	10.0	0.0	2.8	3.5	1.3	2.2
MSX503-05	2	361	395	91	9	88	3	0	1.072	0	0	0.0	0.0	1.3	1.5	0.5	28.3
MSY474-8	1	360	458	79	17	65	13	4	1.064	0	0	0.0	0.0	2.3	4.0	0.5	1.5
Queen Anne	2	316	444	71	28	71	0	1	1.062	0	10	0.0	0.0	1.0	2.5	0.1	31.7
MSY489-1	2	314	361	87	11	81	6	2	1.065	5	5	0.0	0.0	1.5	3.0	0.6	32.0
MSY491-2Y	2	302	345	88	11	88	0	1	1.068	0	5	0.0	0.0	1.7	2.5	1.6	15.5
MSW128-1Y	2	276	455	61	37	61	0	2	1.088	0	5	60.0	0.0	2.5	4.0	2.2	21.2
MSY483-3	2	179	246	73	26	73	0	1	1.069	0	10	0.0	0.0	1.2	2.0	0.3	18.6
MEAN		414	467						1.073					1.8	3.0	1.0	-
$HSD_{0.05}$		296	270						0.012					2.0			29.0

[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 29, 2017; 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.
[6]LB RAUDPC: Late blight (*P. infestans* US-23) foliar disease reaction.

Plant Date: 5/9/17
Vine Kill: 8/31/17
Days from planting to vine kill: 114

[7]Enviroweather: Entrican Station. Planting to vine kill

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, PIGMENTED LINES
MONTCALM RESEARCH CENTER
May 9 to September 7, 2017 (121 days)
DD Base 40°F 2935[9]

		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	PERCENT (%) TUBER QUALITY[4]							LB[8] RAUDPC
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	MAT[6]	Bruise[7]	x100
MSZ109-08PP	2	619	676	92	6	89	3	2	1.065	1.0	0	0	0	0	0	0.7	4.0	1.2	27.9
MSZ443-1PP	2	532	587	91	9	86	4	0	1.067	2.5	2	0	0	0	0	0.8	3.5	2.0	29.7
MSZ428-1PP	2	499	514	97	2	84	13	1	1.078	1.5	0	0	0	0	0	1.5	3.0	0.6	16.4
MSZ109-10PP	2	499	571	87	12	85	2	1	1.066	2.5	1	0	0	0	0	1.7	4.0	0.8	25.5
W8405-1R	2	497	572	87	12	82	5	1	1.070	-	-	0	0	0	0	2.0	3.0	1.9	20.8
ND7132-1R	2	464	514	90	4	85	5	6	1.067	-	-	0	10	0	0	2.7	3.0	0.9	21.6
AF4831-2R	2	458	542	84	15	84	0	1	1.066	-	-	0	10	0	0	2.8	3.0	1.4	25.0
QSNDSU07-04R	2	436	466	94	5	92	1	1	1.067	-	-	0	0	0	5	1.3	2.5	0.6	27.0
Dark Red Norland	2	384	416	92	8	91	1	0	1.064	-	-	0	0	0	0	1.8	1.5	0.5	44.6
Dakota Ruby	2	382	480	79	17	78	1	4	1.070	-	-	0	5	0	0	1.8	3.0	0.7	40.8
AF5245-1P	2	354	406	87	13	84	3	0	1.075	-	-	0	15	0	0	1.3	2.0	1.1	33.3
Dark Red Chieftain	2	344	404	85	15	80	6	0	1.068	-	-	0	0	5	0	1.7	3.0	0.6	24.9
MSXUNK-03P	2	343	425	81	13	81	0	7	1.076	-	-	0	0	0	0	1.2	1.0	1.2	39.1
ND6002-1R	2	327	357	91	8	90	2	1	1.068	-	-	5	0	0	0	1.2	3.0	1.0	28.3
MSZ107-06PP	2	326	438	73	26	71	2	1	1.077	1.5	2	0	0	0	0	2.7	3.5	1.4	29.9
MSW476-4R	2	324	392	82	16	80	1	2	1.074	-	-	0	15	0	0	1.5	3.5	1.7	34.1
W8890-1R	2	320	371	86	13	84	2	1	1.069	-	-	0	25	0	0	2.3	2.0	-	33.3
MSU202-1P	2	319	370	86	12	83	3	2	1.068	-	-	0	5	0	0	1.8	2.5	0.8	15.8
MSZ602-2PP	2	290	335	86	13	80	6	0	1.065	1.0	0	0	0	0	0	2.0	4.0	1.4	11.9
Modoc	2	265	394	67	29	67	0	4	1.067	-	-	0	15	0	0	2.2	2.0	1.5	49.6
MSX001-9WP	1	247	381	65	29	65	0	6	1.073	3.0	3	0	0	0	0	1.3	3.0	2.4	12.7
MSW343-2R	2	246	299	82	15	79	2	3	1.059	-	-	0	5	5	0	1.2	1.5	0.4	45.8
MSZ405-1PP	2	240	292	81	18	80	1	1	1.058	2.5	3	0	0	0	0	1.7	2.5	1.5	30.7
MSX426-1RR	2	231	303	76	23	76	0	1	1.080	1.5	0	0	5	0	0	1.2	3.5	2.3	28.3
MSX035-1WP	1	205	283	72	5	72	0	23	1.075	1.5	0	10	0	0	0	1.3	4.0	-	-
MSZ107-01PP	2	194	249	78	22	72	6	0	1.076	1.5	1	5	0	0	0	1.0	4.5	0.8	19.6
MSZ107-02PP	2	191	333	57	40	57	0	3	1.081	2.0	2	0	15	0	0	1.2	4.5	-	22.8
MSW453-1P	1	190	241	79	21	79	0	0	1.085	-	-	40	0	0	0	2.2	2.5	-	24.2
MSV235-2PY	2	169	267	63	34	63	0	2	1.073	-	-	0	0	0	0	1.8	2.5	1.5	10.5
QSNDSU07-12R	1	147	212	69	31	69	0	0	1.067	-	-	0	0	0	0	-	2.5	-	13.3
MSZ109-05RR	2	82	267	31	69	31	0	0	1.066	2.0	1	0	0	0	0	0.7	3.5	0.6	33.2
MEAN		327	399						1.846							3.0	1.2	27.3	-
$HSD_{0.05}$		230	224						0.011							2.0			29.0

[1]SIZE: B: < 2 in.; A: 2-3.25 in.; OV: > 3.25 in.; PO: Pickouts.
[2]CHIP SCORE: SNAC Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
[3]SED: Stem End Defect, Based on Paul Bethke's (USDA/UWisconsin - Madison) 0 - 5 scale. 0 = no SED; 3 = significant SED; 5 = severe SED
[4]QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. Percent of 40 Oversize and/or A-size tubers cut.
[5]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[6]MATURITY RATING: August 29, 2017; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

Plant Date: 5/9/17
Vine Kill: 8/31/17
Days from planting to vine kill: 114

Table 8

2015-2017 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N	2015 RATING	2015 WORST	2015 N
Sorted by ascending 2017 Average Rating;										
MSZ219-13	0.7*	0.5	0.5	3	0.9	1.0	4			
Lollipop	-	0.7	1.0	3						
MSV380-1	1.0	0.7	1.0	3	1.1	1.5	4	1.3	1.5	4
MSY046-3	-	0.7	1.0	3						
MSZ109-05RR	0.5*	0.7	1.0	3	0.4	0.5	4			
MSZ109-08PP	0.8*	0.7	1.0	3	1.0	1.0	4			
MSZ219-14	0.7*	0.7	1.0	3	0.8	1.0	4			
Pike	**1.1**	**0.7**	**1.0**	**3**	**1.2**	**1.5**	**8**	**1.5**	**1.5**	**4**
W8822-1	1.2*	0.7	1.0	3	1.8	2.5	4			
MSV266-3P	1.3*	0.8	1.0	3				1.8	2.0	4
MSV331-3	0.7*	0.8	1.5	3	0.6	1.0	4			
MSV427-1	-	0.8	1.5	3						
MSW125-1	-	0.8	1.5	3						
MSX324-1P	0.9	0.8	1.5	6	0.9	1.5	4	1.1	2.0	8
MSY027-2	-	0.8	1.0	3						
MSZ052-11	-	0.8	1.0	3						
MSZ052-53	-	0.8	1.0	3						
MSZ222-19	1.1	0.8	1.0	3	1.3	2.0	4	1.3	2.0	4
MSZ263-4	1.0*	0.8	1.0	3				1.1	1.5	4
MSZ282-6	1.1*	0.8	1.5	3				1.4	1.5	4
MSZ443-01PP	1.0*	0.8	1.5	3	1.3	1.5	4			
MSZ622-1	-	0.8	1.5	3						
QSMSU10-05	-	0.8	1.0	3						
AF5312-1Rus	-	1.0	1.5	3						
MSR127-2	1.2	1.0	2.0	3	1.3	2.0	4	1.3	1.5	4
MSV313-2	1.1*	1.0	1.5	3	1.1	2.0	4			
MSZ022-07	-	1.0	2.0	3						
MSZ052-37	-	1.0	1.5	3						
MSZ107-01PP	0.9*	1.0	1.5	3	0.9	1.0	4			
MSZ118-05	-	1.0	1.0	3						
MSZ219-01^{PVYR}	1.0	1.0	1.5	3	0.9	1.5	4	1.1	1.5	4
MSZ219-46	-	1.0	1.5	3						
Queen Anne	-	1.0	1.5	3						
WAF10073-3Rus	-	1.0	1.5	3						
A02507-2LB (Payette)	-	1.2	2.0	3						
CW08221-5Rus	0.8*	1.2	2.0	3	0.5	1.5	4			
MSN230-1RY	1.1*	1.2	1.5	3	1.0	1.5	4			
MSV394-3	1.6	1.2	1.5	3	2.0	2.5	4	1.8	2.0	4
MSV498-1	1.1*	1.2	1.5	3	1.1	1.5	4			
MSV507-012	1.3*	1.2	1.5	3	1.5	2.0	4			
MSW075-1	1.5	1.2	1.5	3	1.6	2.5	4	1.6	2.0	4
MSW123-3	1.2*	1.2	1.5	3				1.3	1.5	4
MSW168-2	1.6*	1.2	1.5	3				2.0	2.0	4
MSW343-02R	1.5*	1.2	1.5	3	1.8	2.0	4			
MSW496-1Rus	1.4	1.2	2.0	3	1.1	1.5	4	2.0	2.0	2
MSX177-7Y	1.2*	1.2	1.5	3	1.3	1.5	4			
MSX225-2	1.1	1.2	1.5	3	1.3	1.5	4	1.0	1.5	4
MSX426-1RR	1.0*	1.2	1.5	3	0.9	1.5	4			
MSXUNK-3P	1.6*	1.2	2.0	3	2.0	2.0	4			
MSY041-1	-	1.2	1.5	3						
MSY483-3	-	1.2	1.5	3						
MSZ062-53	-	1.2	2.0	3						
MSZ107-02PP	-	1.2	1.5	3						
MSZ118-01	-	1.2	1.5	3						
MSZ219-44	-	1.2	1.5	3						
MSZ248-10	-	1.2	1.5	3						

Table 8

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2015-2017 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N	2015 RATING	2015 WORST	2015 N
MSZ407-2Y	1.1*	1.2	1.5	3				1.0	1.5	4
MSZ615-2	-	1.2	1.5	3						
ND050032-4Rus	1.1*	1.2	2.0	3	1.0	1.5	4			
ND6002-1R	1.6*	1.2	1.5	3	2.1	2.5	4			
QSMSU10-09	-	1.2	1.5	3						
Superior	**1.5**	**1.2**	**1.5**	**6**	**1.6**	**2.0**	**4**	**1.6**	**2.0**	**4**
W13008-1rus	-	1.2	1.5	3						
W13103-2Y	-	1.2	1.5	3						
AF5245-1P	-	1.3	1.5	3						
MST424-6	-	1.3	1.5	3						
MSU383-A	1.2	1.3	1.5	3	1.3	2.0	4	1.1	2.0	4
MSV301-2	1.5	1.3	1.5	3	1.8	2.0	4	1.5	2.0	4
MSV393-1	1.4	1.3	1.5	3	1.1	1.5	4	1.8	2.0	4
MSW064-1	1.4*	1.3	1.5	3				1.4	2.0	4
MSW569-2	1.6*	1.3	2.0	3				1.9	2.5	4
MSX001-9WP	1.4*	1.3	1.5	3	1.5	2.5	4			
MSX035-1WP	1.3*	1.3	2.0	3	1.3	1.5	4			
MSX105-01	1.2*	1.3	1.5	3	1.1	2.0	4			
MSX351-3P	-	1.3	1.5	3						
MSX420-4Y	1.9	1.3	1.5	3	2.1	2.5	4	2.4	3.0	4
MSX503-5	1.2	1.3	1.5	3	1.1	1.5	4	1.0	2.0	4
MSX526-1	1.4	1.3	1.5	3	1.6	2.0	4	1.3	1.5	4
MSY012-02	1.5*	1.3	1.5	3	1.6	2.0	4			
MSY111-1	1.5	1.3	2.0	3	1.6	2.0	4	1.5	1.5	4
MSY156-02	1.3*	1.3	1.5	3	1.3	1.5	4			
MSY507-02	-	1.3	1.5	3						
MSZ022-16	-	1.3	1.5	3						
MSZ102-5	-	1.3	1.5	3						
MSZ118-08	-	1.3	1.5	3						
MSZ242-07	-	1.3	2.0	3						
MSZ246-1	-	1.3	2.0	3						
MSZ251-01	-	1.3	1.5	3						
MSZ590-1	-	1.3	1.5	3						
NY162	-	1.3	2.0	3						
Oneida Gold	-	1.3	1.5	3						
QSNDSU07-04R	1.6*	1.3	2.0	6	1.9	2.0	4			
TX08352-5Rus	1.2*	1.3	1.5	3	1.1	2.0	4			
W13014-5rus	-	1.3	1.5	3						
W13103-16Y	-	1.3	2.0	3						
W9523-1rus	-	1.3	2.0	3						
W9576-11Y	-	1.3	1.5	3						
Dark Red Norland	**1.3***	**1.4**	**2.0**	**6**	**1.3**	**1.5**	**4**			
A06021-1TRus	-	1.5	2.0	3						
A06030-23Rus	-	1.5	2.0	3						
AF4138-8	-	1.5	2.0	3						
Goldrush	1.0*	1.5	2.0	3	0.5	1.0	4			
MSV307-02	1.6	1.5	1.5	3	1.6	2.0	4	1.8	2.0	4
MSV358-3	1.7	1.5	2.0	3	1.9	2.0	4	1.6	2.0	4
MSV396-4Y	1.6*	1.5	2.0	3				1.8	2.0	4
MSW399-2	1.6	1.5	2.0	3	1.4	2.0	4	1.9	2.0	4
MSW476-4R	-	1.5	2.5	3						
MSX245-2Y	1.5	1.5	1.5	3	1.5	2.0	4	1.6	2.0	4
MSX417-1	1.7	1.5	2.0	3	1.9	2.0	4	1.6	2.0	4
MSX569-1R	1.8	1.5	2.5	6	1.9	2.0	4	2.0	2.0	2
MSY489-1	-	1.5	2.0	3						
MSZ042-7	-	1.5	2.0	3						
MSZ052-02	-	1.5	2.0	3						

Table 8

2015-2017 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N	2015 RATING	2015 WORST	2015 N
MSZ063-02	-	1.5	2.0	3						
MSZ242-13	1.3*	1.5	2.0	3	1.0	1.5	4			
MSZ428-1PP	-	1.5	1.5	3						
MSZ513-2	-	1.5	1.5	3						
W10209-2R	-	1.5	2.5	3						
MSV434-01Y	1.9	1.6	2.0	6	2.1	2.5	4	1.9	2.0	4
ATX91137-1Rus (Reveille Russet)	1.6	1.7	2.5	3	1.6	2.0	4	1.6	2.0	4
Dark Red Chieftain	**1.6***	**1.7**	**2.0**	**3**	**1.5**	**2.0**	**4**			
Lamoka	**1.7**	**1.7**	**2.0**	**3**	**1.6**	**2.0**	**4**	**1.8**	**2.0**	**4**
MST075-1R	1.7	1.7	2.5	6	1.6	2.0	4	1.9	2.5	4
MSV111-02[LBMR]	1.3*	1.7	2.0	3	1.0	1.5	4			
MSV403-3	-	1.7	2.0	3						
MSV502-5	1.8	1.7	2.0	3	1.8	2.0	4	1.9	2.0	4
MSV507-073	1.7*	1.7	2.0	3	1.8	2.0	4			
MSW125-3	1.4*	1.7	2.0	3				1.1	1.5	4
MSW299-2	2.0*	1.7	2.0	3				2.3	2.5	4
MSW316-3PY	1.8*	1.7	3.0	6	1.9	2.5	4			
MSX172-7	1.6	1.7	2.0	3	1.5	2.0	4	1.8	2.5	4
MSY111-01	-	1.7	2.0	3						
MSY256-A	-	1.7	2.0	3						
MSY491-2Y	1.6*	1.7	2.0	3				1.5	2.0	4
MSZ109-10PP	1.8*	1.7	3.0	3	1.9	2.5	4			
MSZ242-09	1.4*	1.7	2.0	3	1.1	1.5	4			
MSZ405-1PP	-	1.7	2.0	3						
NDAF102629C-4	-	1.7	2.5	3						
NY161	-	1.7	2.0	3						
Cerrata	-	1.8	2.0	3						
Dakota Ruby	1.9	1.8	2.0	3	2.0	2.5	4	2.0	2.0	4
Julinka	-	1.8	2.5	3						
MSS576-05SPL[LBR]	1.9	1.8	3.0	3	2.3	2.5	4	1.8	2.5	4
MST306-1	-	1.8	2.0	3						
MST458-4	-	1.8	2.0	3						
MSU202-1P	1.4	1.8	2.5	3	1.0	1.0	4	1.4	1.5	4
MSV179-1	1.7	1.8	2.0	3	1.3	1.5	3	1.9	2.0	4
MSV235-2PY[LBR]	2.3	1.8	3.0	3	2.5	3.0	4	2.6	3.0	4
MSV335-1	1.8*	1.8	2.5	3				1.8	2.0	4
MSW128-2	-	1.8	2.0	3						
MSW324-01[LBR]	1.9	1.8	2.0	3	2.3	2.5	4	1.8	2.0	4
MSW485-2	1.9	1.8	2.5	3	1.8	2.0	4	2.0	2.0	4
MSX050-01	1.9*	1.8	2.0	3	2.0	2.0	4			
MSX120-5Y	1.9*	1.8	2.0	3	1.9	2.0	4			
MSX345-6Y	1.8	1.8	2.0	3	1.8	2.0	4	1.9	2.5	4
MSX497-02	-	1.8	2.0	3						
MSX501-05	1.9*	1.8	2.0	3	2.0	2.5	4			
MSY089-02	2.0*	1.8	2.0	3	2.1	2.5	4			
MSZ022-19	-	1.8	2.0	3						
Musica	-	1.8	2.0	3						
NY149	-	1.8	2.0	3						
W13100-5Y	-	1.8	2.0	3						
W9742-3Rus	1.8	1.8	2.0	3	1.5	2.0	4	2.0	3.5	4
Russet Norkotah	**2.1**	**1.9**	**2.5**	**6**	**2.1**	**2.5**	**4**	**2.1**	**2.5**	**4**
Alegria	1.9*	2.0	2.0	3	1.8	2.0	4			
Madison	-	2.0	2.5	3						
MSV016-2	2.1*	2.0	2.5	3				2.1	2.5	4
MSV030-4	1.8	2.0	2.0	3	1.8	2.0	4	1.6	2.0	4
MSV507-007	2.0*	2.0	2.0	3	2.0	2.0	4			
MSW042-1[LBR]	2.2	2.0	2.5	3	2.3	2.5	4	2.4	2.5	4

Table 8

2015-2017 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N	2015 RATING	2015 WORST	2015 N
MSW464-3[LBR]	2.1	2.0	2.5	3	2.5	3.0	4	1.9	2.5	4
MSX129-1	2.0	2.0	2.5	3	2.3	3.0	4	1.6	2.0	4
MSX542-2	2.0	2.0	2.5	3	2.0	2.0	4	1.9	2.0	4
MSY008-3	1.7	2.0	2.0	3	1.5	1.5	4	1.5	2.0	4
MSZ013-3	-	2.0	2.5	3						
MSZ157-3[LBR]	2.1*	2.0	2.5	3				2.3	3.0	4
MSZ269-1Y	-	2.0	2.5	3						
MSZ602-02PP	1.7*	2.0	2.5	3	1.3	2.0	4			
ND113207-1R	-	2.0	2.0	3						
Onaway	**1.8***	**2.0**	**2.0**	**3**	**1.6**	**2.0**	**4**			
Soraya	1.7	2.0	2.0	3	1.5	2.0	4	1.6	2.0	4
W8405-1R	-	2.0	2.5	3						
W9968-5	-	2.0	2.5	3						
A08433-4VRRUS	-	2.2	2.5	3						
Allora	-	2.2	2.5	3						
ATND99331-2PintoY	-	2.2	2.5	3						
Jelly	-	2.2	2.5	3						
Melou	-	2.2	2.5	3						
Modoc	2.0*	2.2	3.0	3	1.9	2.5	4			
MSU161-1[LBMR, PVYR]	2.1	2.2	3.0	3	1.9	2.0	4	2.3	2.5	4
MSV127-2	2.1*	2.2	2.5	3				2.1	2.5	4
MSW154-04	2.4*	2.2	2.5	3	2.6	3.0	4			
MSW239-3SPL	2.1	2.2	2.5	3	1.8	2.5	4	2.3	3.0	4
MSW294-1	2.1*	2.2	2.5	3				2.1	2.5	4
MSW453-1P	-	2.2	3.5	3						
MSX245-1	-	2.2	2.5	3						
MSX526-2Y	-	2.2	3.0	3						
MSX540-4[PVYR, LBR]	1.8	2.2	2.5	3	1.3	2.0	4	2.0	2.5	4
MSY001-4	-	2.2	2.5	3						
MSY077-5	-	2.2	2.5	3						
MSZ025-2	-	2.2	2.5	3						
MSZ091-3	-	2.2	3.5	3						
MSZ464-3	-	2.2	3.0	3						
NY157	2.1	2.2	2.5	3	2.0	2.5	4	2.1	2.5	4
Reba	**2.1**	**2.2**	**3.0**	**6**	**2.1**	**2.5**	**8**	**2.1**	**3.0**	**8**
Yukon Gold	**2.4***	**2.2**	**2.5**	**6**	**2.6**	**3.0**	**4**			
W8890-1R	-	2.3	2.5	3						
Manistee	**2.4**	**2.3**	**2.5**	**3**	**2.6**	**3.0**	**4**	**2.1**	**2.5**	**4**
Montreal	-	2.3	3.0	3						
MST145-02[LBR]	2.2*	2.3	3.0	3	2.1	2.0	4			
MSV033-1	2.0	2.3	2.5	3	1.9	2.0	4	1.9	2.0	4
MSW148-01P	2.4*	2.3	2.5	3	2.5	2.5	4			
MSX150-01	2.5*	2.3	2.5	3	2.6	3.0	4			
MSY474-8	-	2.3	2.5	3						
MSZ004-1	-	2.3	2.5	3						
MSZ454-1Y	-	2.3	2.5	3						
MSZ510-4	-	2.3	2.5	3						
W13006-2rus	-	2.3	2.5	3						
W13027-32rus	-	2.3	3.0	3						
AF5091-8Rus	2.4*	2.5	3.0	3	2.3	2.5	4			
Atlantic	**2.7**	**2.5**	**3.0**	**4**	**2.8**	**3.0**	**8**	**2.8**	**3.5**	**8**
Ciklaman	-	2.5	2.5	3						
CO8155-2RU/Y	-	2.5	2.5	3						
MST148-3	2.5*	2.5	3.0	3				2.5	3.0	4
MSU016-2	2.3	2.5	3.0	3	2.4	2.5	4	2.1	2.5	4
MSW128-1Y	-	2.5	3.0	3						
MSX111-03	2.5*	2.5	2.5	3	2.5	3.0	4			

Table 8

2015-2017 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N	2015 RATING	2015 WORST	2015 N
MSX497-6^{LBR}	2.5	2.5	3.0	3	2.1	2.5	4	2.9	3.5	4
MSY071-1	-	2.5	3.0	3						
MSZ210-8	-	2.5	3.0	3						
Snowden	**2.5**	**2.5**	**3.0**	**6**	**2.4**	**2.5**	**8**	**2.8**	**3.5**	**8**
W13030-3rus	-	2.5	3.0	3						
A07061-6Rus	-	2.7	3.0	3						
Elfe	-	2.7	3.0	3						
MSW121-5R^{LBR}	2.6*	2.7	3.0	3				2.6	3.5	4
MSW501-05	2.5*	2.7	3.5	3	2.3	3.0	4			
MSX137-6	2.1	2.7	3.0	3	1.9	2.0	4	1.8	2.0	4
MSZ107-6PP	2.1	2.7	3.0	3	1.8	2.0	4	1.8	2.0	4
MSZ424-01R	3.0*	2.7	3.0	3	3.4	4.0	4			
MSZ562-4	-	2.7	3.0	3						
ND1243-1PY	-	2.7	3.0	3						
ND7132-1R	2.5*	2.7	3.0	3	2.3	2.0	4			
W10564-19Y	-	2.7	3.5	3						
WND8625-2Rus	2.1*	2.7	3.5	3	1.6	2.5	4			
AF4831-2R	2.5*	2.8	3.5	3	2.3	3.0	4			
MST191-2Y	2.7	2.8	3.5	3	2.6	3.5	4	2.5	3.0	4
MSU088-01	2.5*	2.8	3.5	3	2.3	2.5	4			
MSW092-1^{LBR}	2.6*	2.8	3.5	3				2.4	3.0	4
Viviana	-	2.8	3.5	3						
Wendy	-	2.8	3.0	3						
MSW432-13	2.9*	3.0	3.5	3	2.9	3.5	4			
MSX507-1R^{LBR}	2.8*	3.2	3.5	3				2.4	3.0	4
ND1241-1Y	-	3.2	4.0	3						
MSX292-01	-	3.5	4.0	3						
COTX09022-3RusRE/Y	3.3*	3.8	4.0	2	2.9	3.5	4			
AF5179-4Rus	-	3.8	4.5	3						
MEAN		1.7			1.7			1.8		
$HSD_{0.05}$ =		**2.0**			**1.7**			**1.4**		

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.

N = Number of replications.

*2-Year Average.

Table 9 MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2017 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2016 RATING	2016 N	LINE		2016 RATING	2016 N
Sorted by ascending 2017 Rating:							
MSBB626-11		0.0	1	MSCC256-02		0.5	1
MSBB942-10	*2x*	0.0	1	MSCC257-01		0.5	1
MSCC409-01		0.0	1	MSCC268-01		0.5	1
MSDD848-01	*2x*	0.0	1	MSCC282-03RR		0.5	1
MSZ109-08PP		0.0	1	MSCC371-01		0.5	1
MSAA101-1RR		0.5	1	MSCC374-01Y(mini)		0.5	1
MSAA309-15		0.5	1	MSCC374-06		0.5	1
MSAA311-01		0.5	1	MSCC453-01		0.5	1
MSAA478-02		0.5	1	MSCC515-02Y		0.5	1
MSAA578-08		0.5	1	MSCC630-01R		0.5	1
MSBB045-02		0.5	1	MSCC722-02RR(MINI)		0.5	1
MSBB051-1		0.5	1	MSCC812-01	*2x*	0.5	1
MSBB058-4		0.5	1	MSDD802-01	*2x*	0.5	1
MSBB120-03		0.5	1	MSDD821-06	*2x*	0.5	1
MSBB165-01		0.5	1	MSDD855-03	*2x*	0.5	1
MSBB209-02		0.5	1	MSZ062-10		0.5	1
MSBB238-01RY		0.5	1	MSZ096-03		0.5	1
MSBB305-2PSpl		0.5	1	MSZ169-18		0.5	1
MSBB306-2R		0.5	1	MSZ413-6P		0.5	1
MSBB313-1Rus		0.5	1	MSZ468-08RY		0.5	1
MSBB351-1		0.5	1	MSAA055-13		1.0	1
MSBB610-25		0.5	1	MSAA076-04		1.0	1
MSBB612-04		0.5	1	MSAA241-01		1.0	1
MSBB614-10		0.5	1	MSBB058-1		1.0	1
MSBB617-08		0.5	1	MSBB073-04		1.0	1
MSBB618-02		0.5	1	MSBB075-1Y		1.0	1
MSBB623-12		0.5	1	MSBB079-02		1.0	1
MSBB917-01	*2x*	0.5	1	MSBB114-01		1.0	1
MSBB919-10	*2x*	0.5	1	MSBB120-02		1.0	1
MSBB925-04	*2x*	0.5	1	MSBB193-01		1.0	1
MSBB943-01	*2x*	0.5	1	MSBB195-01		1.0	1
MSBB943-14	*2x*	0.5	1	MSBB207-01Y		1.0	1
MSCC012-01		0.5	1	MSBB210-A		1.0	1
MSCC122-01		0.5	1	MSBB213-1SPL		1.0	1
MSCC140-01		0.5	1	MSBB230-1		1.0	1
MSCC156-01		0.5	1	MSBB250-1PP		1.0	1
MSCC164-01		0.5	1	MSBB270-1Spl		1.0	1
MSCC246		0.5	1	MSBB371-1YSPL		1.0	1
MSCC246-03		0.5	1	MSBB613-04		1.0	1
MSCC248-03		0.5	1	MSBB630-02		1.0	1

2017 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2016 RATING	2016 N	LINE	2016 RATING	2016 N
Sorted by ascending 2017 Rating:						
MSBB633-08		1.0	1	MSZ022-02	1.0	1
MSBB634-08		1.0	1	MSZ052-31	1.0	1
MSBB635-14		1.0	1	MSZ101-06	1.0	1
MSBB635-15		1.0	1	MSZ118-08	1.0	1
MSBB918-02	*2x*	1.0	1	MSZ120-04	1.0	1
MSBB923-01	*2x*	1.0	1	MSZ219-13	1.0	1
MSBB934-04	*2x*	1.0	1	MSZ219-14	1.0	1
MSBB936-02	*2x*	1.0	1	MSZ282-06	1.0	1
MSBB938-01	*2x*	1.0	1	MSZ427-01R	1.0	1
MSBB943-13	*2x*	1.0	1	MSZ443-1PP	1.0	1
MSCC009-01		1.0	1	MSZ602-2PP	1.0	1
MSCC081-01		1.0	1	MSBB179-1	1.3	2
MSCC084-01		1.0	1	MSCC581-01Y	1.3	2
MSCC109-01		1.0	1	MSZ242-09	1.3	2
MSCC221-01		1.0	1	MSAA072-04	1.5	1
MSCC240-B		1.0	1	MSAA076-06	1.5	1
MSCC248-02		1.0	1	MSAA127-01PP	1.5	1
MSCC256-04		1.0	1	MSAA161-4RY	1.5	1
MSCC257-02		1.0	1	MSAA169-06	1.5	1
MSCC262-01		1.0	1	MSAA182-3R	1.5	1
MSCC266-02		1.0	1	MSAA208-02	1.5	1
MSCC300-01		1.0	1	MSAA260-03	1.5	1
MSCC542-01P		1.0	1	MSAA266-01	1.5	1
MSCC623-1		1.0	1	MSAA313-01	1.5	1
MSCC808-01	*2x*	1.0	1	MSAA373-03	1.5	1
MSCC811-03	*2x*	1.0	1	MSAA498-18	1.5	1
MSCC813-02	*2x*	1.0	1	MSAA678-01	1.5	1
MSCC815-01	*2x*	1.0	1	MSBB008-03	1.5	1
MSCC832-14	*2x*	1.0	1	MSBB067-1	1.5	1
MSDD803-01	*2x*	1.0	1	MSBB078-01	1.5	1
MSDD804-09	*2x*	1.0	1	MSBB089-2	1.5	1
MSDD805-05	*2x*	1.0	1	MSBB090-1	1.5	1
MSDD805-08	*2x*	1.0	1	MSBB094-1	1.5	1
MSDD821-10	*2x*	1.0	1	MSBB166-1	1.5	1
MSDD829-01	*2x*	1.0	1	MSBB177-2	1.5	2
MSDD838-01	*2x*	1.0	1	MSBB190-03	1.5	1
MSDD849-02	*2x*	1.0	1	MSBB207-01	1.5	1
MSDD852-02	*2x*	1.0	1	MSBB240-1P	1.5	1
MSDD852-06	*2x*	1.0	1	MSBB349-2	1.5	1
MSDD865-02	*2x*	1.0	1	MSBB613-07	1.5	1

Table 9

2017 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2016 RATING	2016 N	LINE		2016 RATING	2016 N
Sorted by ascending 2017 Rating:							
MSBB614-11		1.5	1	MSCC622-01Y		1.5	1
MSBB617-02		1.5	1	MSCC804-01	*2x*	1.5	1
MSBB626-06		1.5	1	MSCC806-05	*2x*	1.5	1
MSBB636-11		1.5	1	MSCC816-03	*2x*	1.5	1
MSBB636-14		1.5	1	MSCC819-02	*2x*	1.5	1
MSBB636-16		1.5	1	MSCC820-03	*2x*	1.5	1
MSBB915-01	*2x*	1.5	1	MSCC822-03	*2x*	1.5	1
MSBB922-01	*2x*	1.5	1	MSCC825-06	*2x*	1.5	1
MSBB945-06	*2x*	1.5	1	MSCC827-06	*2x*	1.5	1
MSBB947-01	*2x*	1.5	1	MSCC832-09	*2x*	1.5	1
MSCC011-01		1.5	1	MSDD807-05	*2x*	1.5	1
MSCC098-01		1.5	1	MSDD808-10	*2x*	1.5	1
MSCC110-01		1.5	1	MSDD844-06	*2x*	1.5	1
MSCC123-01		1.5	1	MSDD847-06	*2x*	1.5	1
MSCC129-04		1.5	1	MSDD848-02	*2x*	1.5	1
MSCC144-01		1.5	1	MSDD849-08	*2x*	1.5	1
MSCC158-02		1.5	1	MSDD863-03	*2x*	1.5	1
MSCC193-01		1.5	1	MSZ022-19		1.5	1
MSCC206-01		1.5	1	MSZ025-02		1.5	1
MSCC215-01		1.5	1	MSZ200-06		1.5	1
MSCC221-02		1.5	1	MSZ263-04		1.5	1
MSCC242-01		1.5	1	MSZ598-02		1.5	1
MSCC242-02		1.5	1	MSBB188-2		1.8	2
MSCC255-02		1.5	1	MSAA036-10		2.0	1
MSCC260-01		1.5	1	MSAA100-01		2.0	1
MSCC261-01		1.5	1	MSAA166-2P		2.0	1
MSCC263-01		1.5	1	MSAA168-03		2.0	1
MSCC266-01		1.5	1	MSAA168-BULK		2.0	1
MSCC309-01		1.5	1	MSAA174-01		2.0	1
MSCC314-01		1.5	1	MSAA183-2PY		2.0	1
MSCC316-01		1.5	1	MSAA252-07		2.0	1
MSCC318-01		1.5	1	MSAA328-04		2.0	1
MSCC328-01		1.5	1	MSAA513-01		2.0	1
MSCC396-01		1.5	1	MSAA571-3Y		2.0	1
MSCC412-01		1.5	1	MSBB058-3		2.0	1
MSCC418-01		1.5	1	MSBB060-01		2.0	1
MSCC553-01R		1.5	1	MSBB061-01		2.0	1
MSCC570-01		1.5	1	MSBB072-02		2.0	1
MSCC577-01		1.5	1	MSBB121-1		2.0	1
MSCC604-01		1.5	1	MSBB196-1		2.0	1

Table 9

2017 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2016 RATING	2016 N	LINE		2016 RATING	2016 N
Sorted by ascending 2017 Rating:							
MSBB231-01		2.0	1	MSCC302-01		2.0	1
MSBB232-03		2.0	1	MSCC302-02		2.0	1
MSBB281-1PY		2.0	1	MSCC303-01		2.0	1
MSBB305-3SPL		2.0	1	MSCC353-01		2.0	1
MSBB308-1R		2.0	1	MSCC374-01		2.0	1
MSBB331-1		2.0	2	MSCC523-01		2.0	1
MSBB349-1		2.0	1	MSCC614-1RYSPL		2.0	1
MSBB351-01		2.0	1	MSCC720-01WP		2.0	1
MSBB375-1		2.0	1	MSCC724-01Y		2.0	1
MSBB610-13		2.0	1	MSCC805-01	*2x*	2.0	1
MSBB610-24Y		2.0	1	MSCC806-02	*2x*	2.0	1
MSBB611-03		2.0	1	MSCC807-01	*2x*	2.0	1
MSBB621-03		2.0	1	MSCC809-04	*2x*	2.0	1
MSBB631-04		2.0	1	MSCC811-04	*2x*	2.0	1
MSBB719-1		2.0	1	MSCC813-04	*2x*	2.0	1
MSBB920-03	*2x*	2.0	1	MSCC822-01	*2x*	2.0	1
MSBB927-06	*2x*	2.0	1	MSCC822-05	*2x*	2.0	1
MSBB930-01	*2x*	2.0	1	MSCC824-01	*2x*	2.0	1
MSBB930-06	*2x*	2.0	1	MSCC826-01	*2x*	2.0	1
MSBB932-05	*2x*	2.0	1	MSCC831-03	*2x*	2.0	1
MSBB933-06	*2x*	2.0	1	MSCC832-01	*2x*	2.0	1
MSBB935-06	*2x*	2.0	1	MSDD807-03	*2x*	2.0	1
MSBB946-02	*2x*	2.0	1	MSDD809-09	*2x*	2.0	1
MSBB947-04	*2x*	2.0	1	MSDD814-04	*2x*	2.0	1
MSBB952-06	*2x*	2.0	1	MSDD829-09	*2x*	2.0	1
MSBB953-10	*2x*	2.0	1	MSDD837-08	*2x*	2.0	1
MSBB963-08	*2x*	2.0	1	MSDD853-02	*2x*	2.0	1
MSCC002-01		2.0	1	MSZ092-02		2.0	1
MSCC112-01		2.0	1	MSZ107-06PP		2.0	1
MSCC132-01		2.0	1	MSZ109-10PP		2.0	1
MSCC152-01		2.0	1	MSZ194-02		2.0	1
MSCC158-01		2.0	1	MSZ436-2SPL		2.0	1
MSCC168-01		2.0	1	MSZUNK-07PP		2.0	1
MSCC203-01		2.0	1	MSBB156-1		2.3	2
MSCC208-01		2.0	1	MSBB190-01		2.3	2
MSCC221-03		2.0	1	MSBB364-1		2.3	2
MSCC240-A		2.0	1	MSBB721-1		2.3	2
MSCC246-07		2.0	1	MSAA091-01		2.5	1
MSCC282-02PP		2.0	1	MSAA131-02		2.5	1
MSCC295-01		2.0	1	MSAA157-2PY		2.5	1

Table 9

2017 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

Sorted by ascending 2017 Rating:

LINE		2016 RATING	2016 N
MSAA176-03		2.5	1
MSAA196-06		2.5	1
MSAA570-03		2.5	1
MSBB029-1Y		2.5	1
MSBB067-2		2.5	1
MSBB131-1		2.5	2
MSBB320-1		2.5	1
MSBB343-2Y		2.5	1
MSBB348-1		2.5	2
MSBB722-3		2.5	1
MSBB920-04	*2x*	2.5	1
MSBB921-08	*2x*	2.5	1
MSBB948-01	*2x*	2.5	1
MSBB963-03	*2x*	2.5	1
MSCC058-01		2.5	1
MSCC129-02		2.5	1
MSCC131-01		2.5	1
MSCC143-01		2.5	1
MSCC204-01		2.5	1
MSCC227-01		2.5	1
MSCC246-01		2.5	1
MSCC292-01		2.5	1
MSCC512-01PP		2.5	1
MSCC528-01Y		2.5	1
MSCC549-02WP		2.5	1
MSCC592-01Y		2.5	1
MSCC709-01		2.5	1
MSCC807-02	*2x*	2.5	1
MSCC811-05	*2x*	2.5	1
MSCC828-01	*2x*	2.5	1
MSCheck Ploidy	*2x*	2.5	1
MSDD805-01	*2x*	2.5	1
MSDD849-06	*2x*	2.5	1
MSDD851-07	*2x*	2.5	1
MSZ063-023		2.5	1
MSZ551-01		2.5	1
MSZ620-01		2.5	1
MSAA120-01		3.0	1
MSAA240-05		3.0	1
MSBB252-1PP		3.0	1
MSBB323-1		3.0	1
MSBB943-05	*2x*	3.0	1
MSBB949-03	*2x*	3.0	1
MSCC070-01		3.0	1
MSCC288-01		3.0	1
MSCC329-01		3.0	1
MSCC397-01		3.0	1
MSCC453-02		3.0	1
MSCC557-01Y		3.0	1
MSCC823-03	*2x*	3.0	1
MSDD837-07	*2x*	3.0	1
MSDD852-04	*2x*	3.0	1
MSZ189-03		3.0	1
MSBB332-1		3.5	1
MSBB353-1		3.5	1
MSCC282-01WR		3.5	1
MSCC515-01Y		3.5	1
MSCC809-02	*2x*	3.5	1
MSCC610-01Y		4.0	1

2017 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

LINE	RAUDPC	N	LINE	RAUDPC	N
Sorted by ascending 2017 RAUDPC					
A02507-2LB (Payette)	0.2	3	CO8155-2RU/Y	14.4	3
MSW121-5R	1.2	3	W9742-3Rus	14.6	3
MSY474-8	1.5	3	MSS576-5SPL	14.7	2
MSW464-3	1.6	3	Cerrata	14.8	3
MSW324-01	2.1	3	MSW299-2	14.9	3
MSZ464-3	2.1	3	MSZ091-3	15.1	3
MSW092-1	2.2	3	W10564-19Y	15.1	3
MSZ562-4	2.8	3	Oneida Gold	15.5	3
MSZ219-13	2.9	3	MSY491-2Y	15.5	3
Ciklaman	3.2	3	MSZ510-4	15.7	3
MSU088-01	3.3	3	MSU202-1P	15.8	1
MSU016-2	3.5	3	MSW154-4	15.9	3
MST148-3	3.7	3	MSW168-2	15.9	3
MSX497-02	5.1	3	MSW485-2	16.3	3
MST145-02	5.6	3	MSZ428-1PP	16.4	3
MSV403-3	6.7	3	A08433-4VRRUS	17.8	3
MSZ219-46	6.7	3	MSV394-3	18.0	3
Musica	6.7	3	MSZ042-7	18.1	3
MSZ424-1R	6.7	3	MSW125-1	18.4	3
MSZ219-44	7.1	3	MSV016-2	18.6	3
MSX497-06	7.6	2	MSY483-3	18.6	3
MSW128-2	8.9	3	MSY111-1	18.7	3
MSZ219-01	9.7	3	MSX526-01	19.5	2
W13014-5rus	9.8	3	W13030-3rus	19.5	2
MSZ219-14	9.8	3	MSZ107-01PP	19.6	3
MSW496-1RUS	10.1	3	**Snowden**	**19.6**	**6**
MSZ263-4	10.3	3	AF5179-4Rus	19.7	3
MSV235-2PY	10.5	1	**Pike**	**19.9**	**3**
MSY071-1	11.1	3	W13103-16Y	20.7	2
MSW042-01	11.2	3	W8405-1R	20.8	3
MSX540-4	11.8	3	MSX526-2Y	20.8	2
MSZ602-2PP	11.9	3	MSW128-1Y	21.2	3
MSU161-1	12.2	3	MSW064-1	21.6	3
MSX507-1R	12.2	3	MSY089-2	21.6	3
MSV396-4Y	12.3	3	ND7132-1R	21.6	3
MSX001-9WP	12.7	3	MSV111-2	22.0	2
MSY077-5	13.0	3	Soraya	22.1	3
MSZ157-3	13.0	3	NY157	22.2	3
QSNDSU07-12R	13.3	1	W13100-5Y	22.4	3
Silverton Russet	**13.8**	**3**	MSY507-02	22.6	3

Table 10

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2017 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

LINE	RAUDPC	N	LINE	RAUDPC	N
Sorted by ascending 2017 RAUDPC					
MSX292-01	22.7	3	MSY046-3	28.3	3
MSZ107-02PP	22.8	3	ND6002-1R	28.3	1
MSZ210-8	23.0	3	AF5091-8Rus	28.3	3
MST191-2Y	23.1	3	Alegria	28.3	3
Wega	23.3	2	MSZ004-1	28.7	3
CW08221-5Rus	23.3	2	**Lamoka**	**29.0**	**3**
MSW399-02	24.0	3	MSY012-2	29.0	3
MSX542-02	24.0	3	Allora	29.0	3
ND050032-4Rus	24.0	3	W9523-1rus	29.1	3
Julinka	24.1	3	NDAF102629C-4	29.1	3
MSW453-1P	24.2	3	Montreal	29.5	2
MSW125-3	24.2	2	MSZ443-1PP	29.7	3
Atlantic	**24.3**	**28**	MSW123-3	29.9	3
MSX501-5	24.8	3	MSZ107-06PP	29.9	3
W8822-1	24.8	3	AF4138-8	30.0	3
Dark Red Chieftain	**24.9**	**3**	MST306-1	30.3	3
MSZ025-2	24.9	3	MSZ405-1PP	30.7	2
Wendy	24.9	3	MSX137-6	30.8	3
AF4831-2R	25.0	3	MSZ407-2Y	30.8	3
MSZ248-10	25.2	3	NY149	30.8	2
MSZ269-1Y	25.5	3	**Yukon Gold**	**30.8**	**3**
MSZ109-10PP	25.5	3	AF5312-1Rus	30.8	1
W13027-32rus	25.5	3	MSV127-2	31.5	3
MSV427-1	25.6	2	MSX189-3	31.5	3
COTX09022-3RusRE/Y	25.7	3	Queen Anne	31.7	2
W13103-2Y	25.8	3	MSY489-1	32.0	2
MSX324-1P	25.8	1	NY161	32.4	3
W10209-2R	25.8	3	MSZ109-05RR	33.2	3
QSMSU10-05	26.0	3	MSW316-3PY	33.3	3
W9968-5	26.3	3	QSMSU10-09	33.3	2
QSNDSU07-04R	27.0	2	W8890-1R	33.3	2
MSZ063-02	27.4	3	AF5245-1P	33.3	2
MSV393-01	27.4	3	**Superior**	**33.8**	**5**
MSZ109-08PP	27.9	3	MSW075-01	34.1	3
MSZ513-2	28.1	3	MSW476-4R	34.1	3
Russet Norkotah	**28.1**	**2**	NY162	34.1	3
MSW569-02	28.1	2	MSW432-13	34.1	3
MSZ251-01	28.2	2	A07061-6Rus	34.9	3
MSX426-1RR	28.3	3	ATX91137-1Rus (Reveille I	35.0	3
MSX503-05	28.3	3	MSV179-1	35.8	2

2017 MSU LATE BLIGHT VARIETY TRIAL
CLARKSVILLE RESEARCH CENTER, MI

LINE	RAUDPC	N	LINE	RAUDPC	N
Sorted by ascending 2017 RAUDPC					
MSZ454-1Y	35.8	1			
W13006-2rus	35.8	3			
WAF10073-3Rus	35.8	3			
Lollipop	35.8	2			
MST458-4	38.1	2			
MSX351-3P	38.3	2			
MSXUNK-03P	39.1	3			
Onaway	**39.1**	**3**			
Reba	**39.3**	**5**			
MSZ622-1	39.5	2			
W13008-1rus	39.5	2			
A06030-23Rus	40.0	3			
MSZ282-6	40.8	1			
Viviana	40.8	1			
Dakota Ruby	40.8	1			
MSV331-3	41.6	3			
WND8625-2Rus	42.4	3			
MSZ615-2	44.5	2			
A06021-1TRus	44.6	2			
Dark Red Norland	**44.6**	**2**			
MSW343-2R	45.8	1			
W9576-11Y	45.8	1			
Goldrush	45.8	2			
TX08352-5Rus	46.6	3			
MSX569-1R	47.0	2			
Modoc	49.6	2			
$HSD_{0.05}$	29.0				

Table 11

2017 MSU LATE BLIGHT EARLY GENERATION TRIAL
CLARKSVILLE RESEARCH CENTER, MI

LINE	RAUDPC	N	LINE	RAUDPC	N
Sorted by ascending 2017 RAUDPC					
MSAA120-01	0.0	1	MSBB190-03	15.5	1
MSBB323-1	2.8	1	MSCC523-01	15.5	1
MSZ219-14	2.8	1	MSAA196-06	17.9	1
MSCC246-	3.7	1	MSBB331-1	18.0	1
MSBB614-11	4.2	1	MSBB631-04	18.2	1
MSCC248-03	4.5	1	MSBB364-1	19.0	1
MSZ219-13	4.5	1	MSBB156-1	19.6	1
MSBB331-1	6.0	1	MSBB209-02	19.6	1
MSZ200-06	6.0	1	MSCC129-02	19.9	1
MSBB613-07	6.5	1	MSCC622-01Y	19.9	1
MSAA174-01	7.3	1	MSBB623-12	20.5	1
MSBB613-04	7.6	1	MSCC256-04	21.7	1
MSBB230-1	8.5	1	MSCC246-03	22.7	1
MSCC109-01	8.5	1	MSCC246-01	23.0	1
MSCC129-04	8.8	1	MSCC353-01	23.0	1
MSBB067-2	9.0	1	MSBB240-1P	25.5	1
MSBB332-1	9.6	1	MSCC303-01	25.5	1
MSBB348-1	9.6	1	MSBB188-2	25.7	1
MSZ436-2SPL	9.6	1	MSBB190-01	25.7	1
MSZ551-01	9.6	1	MSBB131-1	25.8	1
MSBB343-2Y	9.9	1	MSCC257-02	25.8	1
MSAA131-02	10.2	1	MSZ242-09	25.8	1
MSBB612-04	10.2	1	MSCC610-01Y	28.3	1
MSCC257-01	10.7	1	MSBB072-02	30.7	1
MSBB061-01	10.8	1	MSBB349-1	30.7	1
MSAA176-03	11.0	1	MSBB213-1SPL	30.8	1
MSBB614-10	11.0	1	MSCC240-B	30.8	1
MSBB073-04	11.5	1	MSCC557-01Y	30.8	1
MSBB618-02	12.4	1	MSCC604-01	30.8	1
MSCC246-07	13.0	1	MSAA100-01	33.3	1
MSBB364-1	14.0	1	MSAA266-01	33.3	1
MSBB617-02	14.3	1	MSBB306-2R	33.3	1
MSAA252-07	14.5	1	**Atlantic**	**34.8**	**5**
MSCC528-01Y	14.9	1	MSCC143-01	35.8	1
MSCC248-02	15.1	1	MSZ620-01	35.8	1
MSBB188-2	15.2	1	MSAA260-03	38.3	1
MSBB190-01	15.2	1	MSAA168-03	40.8	1
MSBB626-06	15.2	1	MSZ427-01R	40.8	1
MSBB078-01	15.5	1	MSAA313-01	43.3	1
MSBB156-1	15.5	1	MSZ025-02	43.3	1

Table 11

2017 MSU LATE BLIGHT EARLY GENERATION TRIAL
CLARKSVILLE RESEARCH CENTER, MI

LINE	RAUDPC	N	LINE	RAUDPC	N
Sorted by ascending 2017 RAUDPC					
MSAA240-05	45.8	1			
MSAA311-01	45.8	1			
MSAA513-01	45.8	1			
MSBB349-2	45.8	1			
MSBB371-1YSPL	45.8	1			
MSCC242-02	45.8	1			
MSAA478-02	48.3	1			
MSAA091-01	50.8	1			
MSAA168-BULK	53.3	1			

Table 12

2017 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
ADAPTATION TRIAL, CHIP-PROCESSING LINES									
MSX542-2	1.083	19	6	0	0	0	0	76	0.2
AF4138-8	1.066	10	1	1	1	0	0	77	0.5
MSZ242-07	1.097	13	8	4	0	0	0	52	0.6
MSV380-1	1.085	7	10	1	0	0	0	39	0.7
MSW064-1	1.085	12	8	2	3	0	0	48	0.8
Manistee	**1.084**	**10**	**9**	**5**	**1**	**0**	**0**	**40**	**0.9**
MSV358-3	1.078	10	10	3	2	0	0	40	0.9
MSW485-2	1.090	8	10	4	1	0	0	35	0.9
MSZ242-13	1.098	8	12	4	2	0	0	31	1.0
MSW075-01	1.080	8	11	3	3	0	0	32	1.0
MSZ219-14	1.084	7	11	4	1	1	0	29	1.1
MSZ219-46	1.080	5	9	4	0	1	0	26	1.1
MSZ242-09	1.094	7	11	5	1	1	0	28	1.1
Lamoka	**1.086**	**4**	**14**	**6**	**1**	**0**	**0**	**16**	**1.2**
MSZ219-01	1.084	9	5	7	2	1	0	38	1.2
MSV313-02	1.084	8	5	7	5	0	0	32	1.4
Atlantic	**1.093**	**6**	**7**	**7**	**4**	**0**	**0**	**25**	**1.4**
MSZ222-19	1.083	4	7	5	1	2	0	21	1.5
W8822-1	1.090	4	9	6	3	1	0	17	1.5
MSV030-04	1.092	4	10	5	4	1	0	17	1.5
Pike	**1.091**	**3**	**2**	**4**	**1**	**1**	**0**	**27**	**1.5**
MSZ219-13	1.078	2	10	8	5	0	0	8	1.6
MSZ052-11	1.080	6	5	6	7	1	0	24	1.7
MSX540-4	1.093	2	9	8	4	1	0	8	1.7
FL2137	1.090	2	2	4	4	1	0	15	2.0
MSV033-01	1.086	3	5	10	5	0	2	12	2.0
MSR127-2	1.086	1	7	5	8	3	1	4	2.3
MSV331-3	1.076	0	7	6	9	2	1	0	2.4
Snowden	**1.090**	**1**	**1**	**10**	**9**	**3**	**1**	**4**	**2.6**
MSX150-1	1.082	0	2	8	5	8	2	0	3.0
NORTH CENTRAL REGION TRIAL (MSU)									
MSX569-1R	1.058	23	2	0	0	0	0	92	0.1
W13103-2Y	1.060	23	2	0	0	0	0	92	0.1
Red Norland	**1.063**	**20**	**3**	**1**	**0**	**0**	**0**	**83**	**0.2**
QSNDSU07-04R	1.066	17	7	1	0	0	0	68	0.4
MSV434-01Y	1.073	8	3	1	0	0	0	67	0.4
ATND99331-2PintoY	1.069	17	5	3	0	0	0	68	0.4
ND113207-1R	1.062	20	0	4	1	0	0	80	0.4
W10209-2R	1.071	14	10	1	0	0	0	56	0.5
W13008-1rus	1.072	16	6	2	1	0	0	64	0.5
AND00272-1R	1.063	12	6	1	1	0	0	60	0.6
MSW316-3PY	1.072	12	12	1	0	0	0	48	0.6
W13100-5Y	1.083	15	7	2	1	0	0	60	0.6
Yukon Gold	**1.080**	**15**	**7**	**2**	**1**	**0**	**0**	**60**	**0.6**
Russet Norkotah	**1.068**	**12**	**10**	**2**	**1**	**0**	**0**	**48**	**0.7**
MST075-1R	1.074	12	8	4	1	0	0	48	0.8
MSN230-1RY	1.083	10	10	4	1	0	0	**40**	**0.8**
ND1232B-2RY	1.071	10	10	4	1	0	0	40	0.8
MSU161-01	1.075	8	13	3	1	0	0	32	0.9

Table 12

2017 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
ND1241-1Y	1.091	10	9	5	1	0	0	40	0.9
MSX324-1P	1.081	7	12	5	1	0	0	28	1.0
MSY111-01	1.077	10	5	7	3	0	0	40	1.1
W13027-32rus	1.071	7	9	6	3	0	0	28	1.2
ND1243-1PY	1.079	2	14	6	3	0	0	8	1.4
W13006-2rus	1.087	4	12	3	4	2	0	16	1.5
W9523-1rus	1.075	1	10	8	4	2	0	4	1.8
W13014-5rus	1.094	4	4	9	7	1	0	16	1.9
W13030-3rus	1.090	0	4	10	5	1	5	0	2.7
RUSSET TRIAL									
TX08352-5Rus	1.067	11	11	2	1	0	0	44	0.7
CW08221-5Rus	1.066	6	17	2	0	0	0	24	0.8
ATX91137-1Rus (Reveille Russet)	1.077	8	6	8	0	0	0	36	1.0
WAF10073-3Rus	1.073	6	11	6	2	0	0	24	1.2
A06021-1TRus	1.083	6	12	3	4	0	0	24	1.2
Russet Norkotah	**1.077**	**6**	**9**	**8**	**2**	**0**	**0**	**24**	**1.2**
AF5091-8Rus	1.072	6	10	6	2	1	0	24	1.3
Goldrush Russet	**1.076**	**6**	**8**	**9**	**2**	**0**	**0**	**24**	**1.3**
ND050032-4Rus	1.081	4	7	6	2	0	0	21	1.3
A08433-4VRRUS	1.086	2	10	10	2	1	0	8	1.6
WND8625-2Rus	1.082	3	6	14	2	0	0	12	1.6
Silverton Russet	**1.078**	**3**	**9**	**9**	**2**	**1**	**1**	**12**	**1.7**
A07061-6Rus	1.084	1	9	10	4	1	0	4	1.8
CO8155-2RU/Y	1.080	2	0	5	4	2	0	15	2.3
A02507-2LB (Payette)	1.092	0	9	5	6	4	1	0	2.3
AF5312-1Rus	1.079	3	5	7	3	5	2	12	2.3
W9742-3Rus	1.102	1	2	6	7	5	1	5	2.7
A06030-23Rus	1.087	1	3	6	6	5	4	4	2.9
AF5179-4Rus	1.094	0	0	6	13	3	3	0	3.1
ADAPTATION TRIAL, TABLESTOCK LINES									
Elfe	1.064	12	1	0	0	0	0	92	0.1
NDAF102629C-4	1.071	12	1	0	0	0	0	92	0.1
W9576-11Y	1.062	12	1	0	0	0	0	92	0.1
Wega	1.059	11	2	0	0	0	0	85	0.2
MSU383-A	1.063	22	2	1	0	0	0	88	0.2
Melou	1.063	10	3	0	0	0	0	77	0.2
NY149	1.081	10	3	0	0	0	0	77	0.2
Cerrata	1.074	11	1	1	0	0	0	85	0.2
Alegria	1.080	13	2	1	0	0	0	81	0.3
Julinka	1.070	9	3	0	0	0	0	75	0.3
MSW125-3	1.061	20	3	2	0	0	0	80	0.3
MSX569-1R	1.059	17	8	0	0	0	0	68	0.3
Jelly	1.082	8	5	0	0	0	0	62	0.4
MST075-1R	1.074	17	6	2	0	0	0	68	0.4
NY161	1.075	7	5	0	0	0	0	58	0.4
MSV301-02	1.086	16	7	2	0	0	0	64	0.4
MSW125-1	1.079	16	7	2	0	0	0	64	0.4
Reba	**1.076**	**7**	**6**	**0**	**0**	**0**	**0**	**54**	**0.5**
Superior	**1.077**	**11**	**7**	**1**	**0**	**0**	**0**	**58**	**0.5**
MSW316-3PY	1.077	13	12	0	0	0	0	52	0.5

2017 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	**1.083**	**12**	**4**	**3**	**0**	**0**	**0**	**63**	**0.5**
Wendy	1.064	6	7	0	0	0	0	46	0.5
MSS576-5SPL	1.077	14	8	3	0	0	0	56	0.6
Allora	1.072	5	6	2	0	0	0	38	0.8
Ciklaman	1.092	7	9	3	0	0	0	37	0.8
Lollipop	1.070	6	4	2	1	0	0	46	0.8
Onaway	1.070	5	5	3	0	0	0	38	0.8
MSW148-1P	1.086	8	12	3	1	0	0	33	0.9
MSU161-1	1.075	11	9	2	2	1	0	44	0.9
Musica	1.077	7	1	3	2	0	0	54	1.0
Madison	1.101	4	4	5	0	0	0	31	1.1
Oneida Gold	1.081	4	5	3	1	0	0	31	1.1
MSX324-1P	1.085	11	4	6	4	0	0	44	1.1
NY157	1.084	3	7	1	1	1	0	23	1.2
Viviana	1.065	2	2	7	1	0	0	17	1.6
Montreal	1.070	1	3	5	3	1	0	8	2.0
PRELIMINARY TRIAL, CHIP-PROCESSING LINES									
MSY046-3	1.068	17	6	2	0	0	0	68	0.4
MSX245-1	1.080	13	12	0	0	0	0	52	0.5
MSY012-2	1.078	15	7	3	0	0	0	60	0.5
MSZ219-44	1.077	13	7	5	0	0	0	52	0.7
MSZ052-31	1.076	12	8	4	1	0	0	48	0.8
MSZ118-05	1.078	8	15	2	0	0	0	32	0.8
MSW299-2	1.082	14	7	0	3	1	0	56	0.8
MSX501-5	1.083	11	8	6	0	0	0	44	0.8
MSZ063-02	1.089	12	7	5	1	0	0	48	0.8
MSZ052-53	1.082	3	8	1	0	0	0	25	0.8
MSV502-05	1.079	10	10	4	1	0	0	40	0.8
MSV427-1	1.076	9	10	6	0	0	0	36	0.9
MSZ282-6	1.086	11	9	2	3	0	0	44	0.9
MSW464-3	1.089	3	7	2	0	0	0	25	0.9
MSX526-2Y	1.075	7	13	5	0	0	0	28	0.9
MSX177-07Y	1.082	11	7	5	1	0	1	44	1.0
MSZ022-19	1.082	6	12	6	0	0	0	25	1.0
MSX189-3	1.077	7	10	7	1	0	0	28	1.1
MSX245-2Y	1.082	7	9	9	0	0	0	28	1.1
MSV498-1	1.076	7	10	5	3	0	0	28	1.2
MSX420-04Y	1.078	6	11	6	2	0	0	24	1.2
MSY077-5	1.080	8	8	6	3	0	0	32	1.2
MSY027-2	1.079	5	11	8	1	0	0	20	1.2
MSZ118-08	1.078	8	7	7	3	0	0	32	1.2
MSZ042-7	1.099	8	7	7	2	1	0	32	1.2
MST424-6	1.080	8	5	8	3	0	0	33	1.3
MST458-4	1.082	6	10	6	2	1	0	24	1.3
MSY156-02	1.083	3	14	6	2	0	0	12	1.3
MSY089-2	1.082	3	12	9	1	0	0	12	1.3
MSY111-1	1.074	4	11	8	1	1	0	16	1.4
MSZ025-2	1.084	5	11	5	3	1	0	20	1.4
MSZ102-5	1.079	5	10	6	4	0	0	20	1.4
MSW168-2	1.086	7	9	4	2	2	1	28	1.4
MSX526-01	1.081	4	9	9	1	2	0	16	1.5

Table 12

2017 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
W9968-5	1.092	6	7	5	7	0	0	24	1.5
MSX120-5Y	1.08	3	10	8	3	1	0	12	1.6
MSZ246-1	1.086	6	8	5	3	3	0	24	1.6
MSX345-6Y	1.088	6	9	4	1	5	0	24	1.6
MSZ091-3	1.080	3	10	7	4	1	0	12	1.6
MSX417-01	1.086	3	9	8	4	1	0	12	1.6
MST306-1	1.089	2	10	9	2	2	0	8	1.7
MSY071-1	1.080	4	8	8	2	3	0	16	1.7
MSZ052-02	1.082	3	11	4	4	3	0	12	1.7
MSX209-1	1.074	4	4	7	8	2	0	16	2.0
MSZ022-07	1.082	3	5	9	5	5	0	11	2.1
MSZ251-01	1.093	1	7	9	5	1	2	4	2.2
MSZ248-10	1.081	4	3	8	5	4	1	16	2.2
MSX225-2	1.085	1	3	3	4	1	1	8	2.3
MSV127-2	1.086	0	6	9	7	2	1	0	2.3
MSV507-007	1.084	0	7	6	4	8	0	0	2.5
MSX111-3	1.091	3	4	5	3	5	3	13	2.5
MSV507-012	1.086	0	3	7	10	2	3	0	2.8
Snowden	**1.091**	**0**	**3**	**4**	**10**	**4**	**4**	**0**	**3.1**
MSV507-073	1.094	0	2	6	8	3	6	0	3.2
MSY256-A	1.087	1	0	4	8	6	6	4	3.4
NY162	1.094	0	2	1	8	4	10	0	3.8
MSZ269-17	1.083	1	0	2	0	7	11	5	4.1

PRELIMINARY TRIAL, TABLESTOCK LINES

ENTRY	SP GR	0	1	2	3	4	5+	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MST148-3	1.080	5	7	5	2	2	0	24	1.5
Queen Anne	1.062	20	3	0	0	0	0	87	0.1
MSY483-3	1.069	16	6	0	0	0	0	73	0.3
Soraya	1.068	16	8	1	0	0	0	64	0.4
MSZ464-3	1.069	8	4	1	0	0	0	62	0.5
MSX503-05	1.072	8	3	2	0	0	0	62	0.5
MSY474-8	1.064	8	3	2	0	0	0	62	0.5
MSZ622-1	1.062	12	12	0	1	0	0	48	0.6
MSW128-2	1.062	5	8	0	0	0	0	38	0.6
MSY489-1	1.065	12	10	3	0	0	0	48	0.6
Reba	**1.072**	**10**	**13**	**1**	**0**	**1**	**0**	**40**	**0.8**
MSX497-02	1.073	6	5	1	1	0	0	46	0.8
MSV111-2	1.084	9	12	3	1	0	0	36	0.8
MSZ210-8	1.072	9	11	5	0	0	0	36	0.8
MSZ513-2	1.073	10	10	4	1	0	0	40	0.8
MSZ590-1	1.065	9	11	5	0	0	0	36	0.8
MSZ562-4	1.069	4	19	2	0	0	0	16	0.9
MSZ615-2	1.072	6	15	4	0	0	0	24	0.9
MSZ004-1	1.071	7	12	5	1	0	0	28	1.0
Superior	**1.077**	**2**	**16**	**7**	**0**	**0**	**0**	**8**	**1.2**
QSMSU10-09	1.078	3	13	8	0	0	0	13	1.2
MSW092-1	1.076	2	6	4	1	0	0	15	1.3
MSY507-02	1.083	5	9	7	4	0	0	20	1.4
MSZ407-2Y	1.084	3	12	4	5	0	0	13	1.5
MSW154-4	1.075	0	15	8	1	1	0	0	1.5
MSX497-06	1.074	3	10	6	3	1	0	13	1.5

2017 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
MSY491-2Y	1.068	1	15	5	2	2	0	4	1.6
MSW128-1Y	1.088	1	9	4	7	3	1	4	2.2
PRELIMINARY TRIAL, PIGMENTED LINES									
MSW343-2R	1.059	16	6	2	0	0	0	67	0.4
Dark Red Norland	**1.064**	**9**	**10**	**0**	**0**	**0**	**0**	**47**	**0.5**
Dark Red Chieftain	**1.068**	**11**	**13**	**1**	**0**	**0**	**0**	**44**	**0.6**
MSZ109-05RR	1.066	11	13	1	0	0	0	44	0.6
MSZ428-1PP	1.078	12	11	1	1	0	0	48	0.6
QSNDSU07-04R	1.067	10	14	1	0	0	0	40	0.6
Dakota Ruby	1.070	10	12	3	0	0	0	40	0.7
MSU202-1P	1.068	9	13	3	0	0	0	36	0.8
MSZ107-01PP	1.076	9	13	3	0	0	0	36	0.8
MSZ109-10PP	1.066	10	11	4	0	0	0	40	0.8
ND7132-1R	1.067	8	11	4	1	0	0	33	0.9
ND6002-1R	1.068	11	6	6	2	0	0	44	1.0
AF5245-1P	1.075	6	13	4	2	0	0	24	1.1
MSXUNK-03P	1.076	5	11	8	1	0	0	20	1.2

2017 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
MSZ109-08PP	1.065	8	6	9	2	0	0	32	1.2
AF4831-2R	1.066	3	13	7	1	1	0	12	1.4
MSZ107-06PP	1.077	5	8	8	4	0	0	20	1.4
MSZ602-2PP	1.065	4	10	8	2	1	0	16	1.4
Modoc	1.067	5	9	7	4	1	0	19	1.5
MSV235-2PY	1.073	4	10	8	1	1	1	16	1.5
MSZ405-1PP	1.058	5	9	6	4	0	1	20	1.5
MSW476-4R	1.074	2	12	5	5	0	1	8	1.7
W8405-1R	1.070	2	7	7	1	2	1	10	1.9
MSZ443-1PP	1.067	2	7	7	6	3	0	8	2.0
MSX426-1RR	1.080	1	4	11	5	3	1	4	2.3
MSX001-9WP	1.073	0	2	5	5	1	0	0	2.4
USPB/SFA TRIAL CHECK SAMPLES (Not bruised)									
AC01144-1W	1.067	21	4	0	0	0	0	84	0.2
NDA081453CAB-2C	1.079	21	3	1	0	0	0	84	0.2
MSV358-3	1.074	19	3	3	0	0	0	76	0.4
MSW485-2	1.086	18	5	2	0	0	0	72	0.4
NDTX0981648CB-13W	1.083	15	9	0	0	0	0	62.5	0.4
NY152	1.080	15	10	0	0	0	0	60	0.4
B2727-2	1.081	17	5	3	0	0	0	68	0.4
AF5040-8	1.081	17	8	2	0	0	0	63	0.4
Lamoka	**1.082**	**14**	**10**	**1**	**0**	**0**	**0**	**56**	**0.5**
Snowden	**1.085**	**14**	**9**	**2**	**0**	**0**	**0**	**56**	**0.5**
MSX540-4	1.087	12	11	2	0	0	0	48	0.6
MSR127-1	1.086	13	7	5	0	0	0	52	0.7
USPB/SFA TRIAL BRUISE SAMPLES									
MSV358-3	1.074	18	6	1	0	0	0	72	0.3
NDTX0981648CB-13W	1.083	17	8	0	0	0	0	68	0.3
NY152	1.08	17	6	2	0	0	0	68	0.4
NDA081453CAB-2C	1.079	15	8	1	1	0	0	60	0.5
AC01144-1W	1.067	15	5	2	1	0	0	65	0.5
AF5040-8	1.081	16	5	2	2	0	0	64	0.6
Lamoka	**1.082**	**13**	**7**	**5**	**0**	**0**	**0**	**52**	**0.7**
MSW485-2	1.086	11	9	3	2	0	0	44	0.8
MSR127-1	1.086	7	14	2	1	1	0	28	1.0
Snowden	**1.085**	**6**	**8**	**7**	**4**	**0**	**0**	**24**	**1.4**
B2727-2	1.081	2	13	5	4	1	0	8	1.6
MSX540-4	1.087	5	3	8	5	2	1	21	2.0

*Thirteen to twenty-five (dependent on the number of replications in a given trial) 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 & 31/2017. The table is presented in ascending order of average number of spots per tuber.

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2017 On-Farm Potato Variety Trials

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INTRODUCTION

Our main objectives for on-farm potato variety trials are to: 1) identify promising lines for further testing and evaluation, 2) conduct larger scale commercial agronomic and processing trials through multi-acre block plantings, and 3) use trial data to encourage the commercialization of new varieties in the state of Michigan. We share our results with growers, breeders, and processors across the country to aid in the development of new varieties. In 2017, we conducted 41 on-farm potato variety trials with 16 growers in 12 counties.

Processing trial cooperators were: 4-L Farms, Inc. (Allegan), County Line Farms (Allegan), Crawford Farms, Inc. (Montcalm), Crooks Farms, Inc. (Montcalm), Johnsons Farms (Bay), Lennard Ag. Co. (St. Joseph), Main Farms (Montcalm), Sandyland Farms (Montcalm), and Walther Farms, Inc. (St. Joseph). We also conducted processing trials at the Michigan State University (MSU) Montcalm Research Center (Montcalm). The Potatoes USA/Snacking Nutrition and Convenience International (SNAC Int.) chip trial was conducted at Sandyland Farms (Montcalm).

Fresh market trial cooperators were: 4-L Farms (Allegan), Crawford Farms, Inc. (Montcalm), Elmaple Farm LLC (Kalkaska), Horkey Bros. (Monroe), Jenkins Farms (Kalkaska), Kitchen Farms, Inc. (Antrim), Lennard Ag. Co. (St. Joseph), T.J.J. VanDamme Farms (Delta), Walther Farms, Inc. (St. Joseph), and Wilk Farms (Presque Isle).

PROCEDURE

A. Processing Variety Trials

We evaluated 45 chip processing varieties in 2017. To evaluate selected processing lines, we used the following check varieties: Altantic, Lamoka, Pike, and Snowden. For all trials, we used 10” in-row seed spacing and 34” rows.

The majority of our processing trials were strip trials. These trials consisted of a single 75-95’ strip for each variety of which we harvested and graded a single 23-ft section. At Crooks Farms, we planted 15’ long strips and harvested the entire strip. For each variety in the Walther Farms, Inc. trials, we planted three, 15-ft long rows and harvested the center row. We also conducted multi-acre block plantings of promising, non-commercialized trials at County Line Farms, Lennard Ag. Co., Crooks Farms, Sackett

Potatoes and Sandyland Farms. Agronomic production practices for these block plantings varied based on each grower's production system.

B. Processing Variety Trials

We conducted the Potatoes USA/SNAC Int. Trial for Michigan at Sandyland Farms, LCC (Montcalm County). We planted 12 varieties in 300' strips and harvested three, 23-ft sections of row for each variety. Our check varieties were 'Lamoka' and 'Snowden'. For more details on this trial, please reference the 2017 annual report published by Potatoes USA.

C. Fresh Market Trials

Within the fresh market trials, we evaluated 84 primary entries (this does not include entries from Potatoes USA/NFPT trial) which included: 25 russet, 16 red, 27 yellow, 7 novelty, and 9 round white types. To evaluate selected table-stock lines, we used the following check varieties:
<u>Red</u>: Dark Red Norland
<u>Round White</u>: Onaway, Reba
<u>Russet</u>: GoldRush, Russet Norkotah, Silverton Russet
<u>Yellow</u>: Yukon Gold
We planted all trials with 34" wide rows and 10" in-row seed spacing.

We evaluated the majority of our fresh market trials as strip trials. These trials consisted of a single 60-100' for each variety of which we harvested and graded a single 23-ft section. We planted the NFPT trial at Walther Farms, Inc. as single 15' long strips and harvested the entire strip. For each variety in the Elmaple Farm LCC trial, we planted three, 30-ft long rows and harvested 23-ft of the center row. We planted Walther Farms, Inc. trials similarly to the Elmaple trial except the rows were 15 ft long and we harvested the entire center row. We also conducted multi-acre block plantings of promising, non-commercialized trials at Elmaple Farms, Jenkins Farms, Kitchen Farms, Lippens Farm, R & E Styma Farms and Walther Farms. Agronomic production practices for these block plantings varied based on each grower's production system.

RESULTS

A. Processing Variety Trial Results

We recorded general descriptions, pedigrees, and scab ratings for all varieties tested in 2017 (Table 1) and evaluated these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Table 2). Below are seven superior processing varieties from 2017.

> **MSV313-2**: This Michigan State University selection was evaluated at two locations and had the highest overall and US #1 yields in 2017 of 743 cwt/A and 713 cwt/A, respectively. It produced very large tubers with 56% over 3 ¼ inches. It will be further evaluated under reduced nitrogen conditions in 2018. This variety

had an average common scab rating of 0.8 and a lightly higher than average stem end defect score of 1.8. It had no internal defects except 20% of tubers exhibiting vascular discoloration. It had a specific gravity of 1.082 and an off the farm chip score of 1.8. MSV313-2 is a medium to late maturing plant with moderately vigorous vines.

MSX219-13: This variety had the second highest US #1 yield in the processing variety trial of 596 cwt/A. It had 96% US #1 tubers and a below average percentage of pickouts. The specific gravity was 1.082 and off the farm chip score was 1.0, below the trial average of 1.3. This variety is resistant to both common scab and stem end defects. It had good internal quality except for 12% vascular discoloration. MSX219-13 is a medium-late maturing plant with moderately vigorous vines.

MSX111-3: This variety had a high yield of 530 cwt/A US #1 tubers. It had a larger size profile with 18% oversize tubers. MSX111-3 had a higher than average specific gravity of 1.087, and an off the farm chip score of 1.0. It had some internal defects, including 20% vascular discoloration, internal brown spot, and brown center, and 10% hollow heart. This variety was only evaluated at one location in 2017, but will be further evaluated in multiple locations in 2018.

W9968-5: This variety from the University of Wisconsin was evaluated at ten locations in 2017. It had 88% US #1 tubers and a US#1 yield of 526 cwt/A. This variety had an above average specific gravity of 1.087 and an off the farm chip score of 1.4. It had an average amount of internal defects and was moderately resistant to common scab. It had moderate stem end defects with a score of 2.8. The tubers could be pear shaped with heavy russeting.

MSX540-4: This Michigan State University variety was planted at twelve locations, and had an average yield of 511 cwt/A US #1 tubers. It had a very high specific gravity of 1.090, and an off the farm chip score of 1.2. It had a low incidence of internal defects except for 12% vascular discoloration, less than the trial average. This variety was resistant to both common scab and stem end defects. MSX540-4 had a moderately vigorous vine and medium maturity. It has good chip color after storage, but exhibited bruising and some dark chips.

NY152: This Cornell University variety continued to display excellent agronomic traits. The US#1 yield was 496 cwt/A, with 86% US #1 tubers. It had an average specific gravity of 1.084 and an off the farm chip score of 1.3. This medium maturing variety had a lower than average incidence of stem end defects, and lower than average internal defects. It has excellent long-term storage potential, with low total defects and an SNAC chip score of 1.0 after several months in storage.

MSW485-2: This Michigan State University variety had a high US#1 yield of 495 cwt/A and 84% US #1 tubers. It had a very high specific gravity of 1.090 and an average common scab rating of 0.8. This variety had an off the farm chip score of 1.3, and a lower than average incidence of internal defects. MSW485-2 is a medium to late maturing variety with some alligator hide observed in 2017.

B. Potatoes USA/SNAC Int. Chip Trial

In 2017, we conducted the Potatoes USA / SNAC Int. Michigan chip trial at Sandyland Farms, LLC in Montcalm County. We compared yield, size distribution, and specific gravity of 10 test varieties to Lamoka and Snowden (Table 3). We also evaluated at-harvest raw tuber quality (Table 4) and sent samples to Herr Foods, Inc. (Nottingham, PA) where potatoes were processed and scored for out of the field chip quality (Table 5). We assessed blackspot bruise susceptibility (Table 6) and pre-harvest panels for each variety (Table 7).

The varieties with the highest US#1 yields were MSX540-4, MSW485-2, MSR127-2, and NY152, with yields ranging from 500 cwt/A to 461 cwt/A. MSR127-2 had the highest percent of US #1 tubers at 90%, while AC01144-1W had the lowest at 71%. The average specific gravity of the trial was 1.081 (Table 3). No internal brown spot or brown center was observed in 2017, and minimal hollow heart was present with a trial average of 2% and the highest incidence at 10% in B2727-2. However all varieties displayed at least 10% vascular discoloration, with 47% incidence in AF5040-8 and Snowden (Table 4). Samples collected on October 17th were processed by Herr's Foods, Inc. on October 23rd. NY152 had the highest Agton color for the second year at 63.2, and was ranked first by Herr's for overall chip quality. MSX540-4 and MSV358-3 were also ranked highly, while MSR127-2 and AC01144-1W were ranked last in the trial (Table 5). Black spot bruise assessments demonstrated that MSV358-3, NDTX081648CB-13W, and NY152 were most resistant to black spot bruising with about 70% bruise free tubers, while B2727-2 and MSX540-4 were most susceptible, with 8% and 21% bruise free tubers, respectively (Table 6).

C. Fresh Market and Variety Trial Results

We recorded general descriptions, pedigrees, and scab ratings for all fresh market varieties evaluated in 2017 (Table 8) and assessed these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Table 9). Below are top performing russet, yellow, red, white, and novelty fresh pack varieties.

Russets

Caribou Russet: This University of Maine variety had the second highest US#1 trial yield at 558 cwt/A. It had a medium russeted skin type and a larger tuber size profile with 24% of tubers over ten ounces. This medium maturing variety is resistant to common scab and has a very vigorous vine. It had a specific gravity of 1.078, slightly above the trial average, and low incidence of hollow heart, internal brown spot, and brown center. However, it had 40% vascular discoloration, well above the trial average of 9%.

A08433-4VRRUS: This Aberdeen, Idaho variety also had a high yield of 557 cwt/A with 83% US #1 tubers. It had a specific gravity of 1.080 and a common scab rating of 0.7. This full season variety had a moderately vigorous vine, and no internal defects except for a 27% incidence of vascular discoloration. A08433-

4VRRUS has multiple disease resistances including PVY, *Verticillium* Wilt, Early Blight, and tuber Late Blight.

A07060-6RUS: This Aberdeen, Idaho variety was evaluated at six locations in 2017. It had a high US#1 yield of 513 cwt/A, and a smaller tuber size profile with 17% B-sized tubers. This variety had a specific gravity of 1.080 and excellent internal quality, with 3% vascular discoloration and no other defects present. It had a higher than average common scab rating of 1.3 and a late vine maturity.

AF5179-4RUS: This University of Maine selection was evaluated in eight locations in 2017 and had a high yield of 468 cwt/A of US#1 tubers. It had a very high specific gravity of 1.089 and good internal quality with defects at or below the trial average. AF5179-4RUS is susceptible to common scab with a score of 2.0, and the potatoes had a tubular shape.

W10612-8RUS: This University of Wisconsin variety had a US #1 yield of 449 cwt/A and 83% US #1 tubers. It had a specific gravity of 1.076, slightly below the trial average, and good internal quality, at or below the trial average for hollow heart, vascular discoloration, internal brown spot, and brown center. This variety is moderately resistant to common scab with a score of 0.7, and had medium vine maturity.

A06021-1TRUS: This Aberdeen, Idaho selection had a yield of 445 cwt/A US #1 potatoes, slightly above the trial average of 442 cwt/A. It had a specific gravity of 1.076 and acceptable internal quality. This medium maturing variety had a common scab score of 0.5.

Yellow Flesh

Soraya: This Norika selection had the highest yield of the yellow flesh trial in 2017 at 494 cwt/A US#1 potatoes. It had a specific gravity of 1.060, lower than the trial average of 1.067, and medium vine vigor and maturity. It had good internal quality, with internal defects below the trial average, and a common scab rating of 0.6.

Jelly: This SunRain variety had a high US #1 yield of 468 cwt/A with 82% US #1 tubers. At 1.078, it had a higher than average specific gravity, and a common scab rating of 0.7. Jelly had a high incidence of vascular discoloration at 27%, well above the trial average of 13%. This full season variety had oval to oblong tubers.

Musica: This Meijer selection was evaluated at eight locations in 2017. It had a US#1 yield of 455 cwt/A and a smaller tuber size profile, with 25% B-sized tubers. This variety had a specific gravity of 1.068 and a lower than average incidence of internal defects. It was a medium maturing variety with a common scab rating of 0.6.

Malou: This Michigan State University variety had a bright skin appearance and high US #1 yield of 449 cwt/A. It had a lower specific gravity of 1.063, and good internal quality except for 21% vascular discoloration. With a rating of 1.1 it was susceptible to common scab.

NY161: This Cornell University variety had purple splashed eyes and high yield of 446 cwt/A US#1 potatoes. It had a specific gravity of 1.074 and good internal quality at or below the trial average. This medium to late maturing variety had a moderately vigorous vine type.

Alegria: This Norika selection was evaluated at eight locations in 2017. It had a US #1 yield of 427 cwt/A and a specific gravity of 1.078. This variety had a higher than average incidence of vascular discoloration, but other internal defects were below the trial average. This medium maturing variety had an oblong tuber type, pink eyes, and a larger tuber size profile.

Elfe: This SunRain selection had a US#1 yield of 380 cwt/A and 76% US #1 potatoes. It had an average specific gravity of 1.067, and a common scab rating slightly below average at 0.7. This early maturing variety had some heat sprouts.

Red Skin

Cerata: This Stet Holland variety was the highest yielding variety in the 2017 red skin potato trial with a US #1 yield of 535 cwt/A. It was evaluated at eight locations in 2017, and had 85% US #1 tubers. Cerata had a specific gravity of 1.073, higher than the trial average of 1.063. It had good internal quality except for 10% vascular discoloration. This full season variety had a common scab rating of 0.8 and slight heat sprouts.

W8405-1R: This University of Wisconsin variety had a high US #1 yield of 442 cwt/A and a specific gravity of 1.064. Its internal quality was acceptable, with 11% vascular discoloration and 8% internal brown spot. This variety had an oval tuber type, very vigorous vine, and medium maturity.

ND7132-1R: This medium maturing North Dakota variety had a US#1 yield of 439 cwt/A and a specific gravity of 1.062. It had an oval tuber shape and attractive red skin color. It had a slightly higher than average incidence of vascular discoloration at 14%. It was susceptible to common scab with a rating of 1.6, and had sticky stolons and slight skinning.

Dark Red Chieftain: This Chieftain selection originated in Iowa in 1966. It has a good overall appearance with netted, dark red skin. In 2017, Dark Red Chieftain was a high yielding red variety with a US#1 yield of 388 cwt/A. This medium maturity clone is also common scab tolerant with a rating of 0.7.

AF4831-2R: This University of Maine selection had a higher than average yield of 370 cwt/A of US #1 potatoes. It had a smaller size profile with no oversize potatoes and 25% B size tubers. This variety had a specific gravity of 1.065 and acceptable internal quality. It had a common scab rating of 1.2, and some skinning was observed in 2017.

W8890-1R: This mid-season maturing Wisconsin variety produced uniform tubers with deep red skin. It had a US#1 yield of 345 cwt/A, slightly below the trial average of 354 cwt/A. W8890-1R had a smaller size profile with 17% B size tubers. It had a higher than average incidence of vascular discoloration at 35%.

Round White

MSY111-1: This Michigan State University selection was the highest yielding variety of the 2017 round white variety trial. It has a US #1 yield of 543 cwt/A with 90% US#1 tubers. This variety had a larger tuber size profile with 17% of tubers larger than 3 ¼ inches, and a netted skin. It had good internal quality with 8% vascular discoloration. This full season variety had a common scab rating of 0.7.

MSU383-A: This Michigan State University variety had a US #1 yield of 421 cwt/A with 95% US #1 tubers. It had some alligator hide and 24% oversize tubers. It had no internal defects in 2017 and a specific gravity of 1.061. This variety has slightly earlier maturity than average.

AF4138-8: This University of Maine selection had a US #1 yield of 411 cwt/A with 78% US #1 tubers. It had a smaller size profile, with 20% B size tubers. This variety had a lower than average specific gravity of 1.063, 13% vascular discoloration, and a common scab rating of 0.8.

MSV179-1: This Michigan State University variety had uniform, round tubers with cream colored flesh. It yielded well in four locations with an average US#1 yield of 392 cwt/A and 23% oversize. MSV179-1 is more adaptable to northern locations. Internal quality was excellent with only 3% vascular discoloration. This variety also appears to be common scab tolerant with a rating of 0.6.

Novelty

AF5414-1RR: This University of Maine selection has red skin and red flesh, with some purple flesh observed in 2017. It has a US #1 yield of 387 cwt/A and 79% US #1 tubers. It had a higher than average specific gravity of 1.077, and a common scab rating of 0.9. It had excellent internal quality with no defects reported in 2017.

MSX324-1P: This Michigan State University variety was evaluated at five location in 2017. It had an average US #1 yield of 303 cwt/A and 97% US #1 tubers. This variety has dark purple skin and excellent internal tuber quality, with no defects reported in 2017. It is resistant to common scab with a rating of 0.4, and is an early maturing variety.

Table 1. Variety information for 2017 MSU Processing Potato Variety Trials

Entry	Pedigree	2017 Scab Rating*	Characteristics
Atlantic	Wauseon X B5141-6 (Lenape)	1.8	High yield, early maturing, high incidence of internal defects, high specific gravity
Hodag	Pike X Dakota Pearl	0.5	Average yield, high specific gravity, size profile similar to Atlantic, management should be adjusted as this variety produces large tubers, long storage potential with common scab resistance
Lamoka (NY139)	NY120 X NY115	1.0	High yield, mid-late season maturity, medium specific gravity, oval to oblong tuber type, low internal defects, long term chip quality
Madison	Sun Rain	0.6	High specific gravity, early vine maturity
Manistee (MSL292-A)	Snowden X MSH098-2	0.9	Average yield, scab resistance similar to Snowden, medium specific gravity, long storage potential, uniform, flat round tuber type, heavy netted skin
Mega Chip	Wischip X FYF85	0.0	Medium to late season maturity, high yield potential, early bulking, longer dormancy than Snowden, common scab resistance, fairly resistant to shatter bruise, good chip quality out of the field and out of storage
Pike (NYE55-35)	Allegany X Atlantic	0.2	Average yield, early to mid-season maturity, small tuber size profile, early storage, some internal defects, medium specific gravity
Pinnacle (W5015-12)	Brodick X W1355-1	0.8	Average yield, high tuber set with smaller tuber size profile, medium-late vine maturity, tubers tend toward flattened shape, scab tolerance similar to Snowden
Saginaw Chipper (MSR061-1)	Pike X NY121	0.3	Medium yield, resistance, to PVY, common scab, foliar late blight, late season maturity, excellent chip quality out of storage, low incidence of internal defects
Snowden (W855)	B5141-6 X Wischip	0.8	High yield, late maturity, mid-season storage, reconditions well in storage, medium to high specific gravity
AC01144-1W	COA96141-2 X Willamette	1.3	Smaller tuber size profile, medium vine maturity

(Processing Varieties Cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
AF4648-2	NY132 X Liberator	0.6	Moderate yield potential, common scab resistant, high specific gravity, low internal defects, in SNAC trial
AF5040-8	AF2376-5 X Lamoka	1.4	High yield, high specific gravity, medium maturing, vigorous vines, pale yellow flesh, round to oblong shape, common scab susceptible, in SNAC trial, in Fast Track 2018
B2727-2	B0766-3 X B2135-163	2.7	Early vine maturity, oval tuber shape, in SNAC trial
MSR127-2	MSJ167-1 X MSG227-2	0.5	Scab resistant, high specific gravity, good chip quality from storage, above average yield potential, medium-late maturity, in SNAC trial
MSV016-2	Atlantic X Missaukee	0.0	Scab resistant, high specific gravity, smooth light skin, larger tuber size profile
MSV030-4	Beacon Chipper X MSG227-2	0.8	High yield potential, high specific gravity, flattened round tuber shape, in SNAC 2018
MSV033-1	Beacon Chipper X MSJ147-1	1.0	High percentage of pickouts, good chip color, high hollow heart incidence, misshapen tubers
MSV307-2	MSN238-A X McBride	0.5	Goo chip color, some misshapen tubers and growth crack, medium maturity
MSV313-2	MSN238-A X OP	0.8	High yield potential, large round tubers with smooth shape, scab resistant, potential storage chipper.
MSV358-3	MSP239-1 X OP	0.8	Scab resistant with high specific gravity. Has chip storage potential from 50ºF.
MSW075-2	MSK061-4 X Nicolet	0.0	Smaller tuber size profile, possible resistance to common scab, medium vine maturity
MSW485-2	MSQ070-1 X MSR156-7	0.8	High yield potential, high specific gravity, excellent chip-processing quality out of the field and long-term storage, resistance to late blight and common scab tolerant

(Processing Varieties Cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
MSX050-1	Beacon Chipper X Nicolet	0.5	Low specific gravity, acceptable internal quality, full season variety.
MSX111-3	Dakota Crisp X MSN19102Y	0.5	High yield potential, high percent US#1 tubers, medium vine maturity
MSX120-5Y	Dakota Diamond X McBride	0.5	Light yellow flesh, some pink eyes, good internal quality, good chip color, smaller vine size
MSX540-4	Saginaw Chipper X Lamoka	0.8	Average yield, high specific gravity, long term chip processing quality with resistance to common scab
MSZ022-7	Kalkaska X Tundra	0.5	Average to high yield potential, larger tuber size profile, resistance to common scab, in Fast Track 2018
MSZ052-11	Pike X MSR127-2	0.5	High yield potential, medium vine maturity, resistance to common scab
MSZ219-1	Saginaw Chipper X MSR127-2	0.3	Common scab, PVY, and late blight resistant, high specific gravity, attractive tuber type
MSZ219-13	Saginaw Chipper X MSR127-2	0.0	High yield potential, high percent US#1 tubers, good chip processing quality out of the field, resistance to common scab
MSZ219-14	Saginaw Chipper X MSR127-2	0.3	High specific gravity, average to high yield potential, long term chip processing quality, resistance to common scab, late blight, and PVY
MSZ219-46	Saginaw Chipper XMSR127-2	0.5	Larger tuber size profile, good chip quality out of the field
MSZ242-09	MSR169-8Y X MSU383-A	0.0	High specific gravity, smaller tuber size profile, resistance to common scab
MSZ242-13	MSR169-8Y X MSU383-A	0.0	Very high specific gravity, good out of the field chip quality, resistance to internal defects, medium vine maturity, in Fast Track 2018
ND7519-1	ND3828-15 X W1353	1.0	High specific gravity, medium to high yield potential, medium vine maturity, round smooth skinned tubers, in SNAC 2018

(Processing Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
ND7799C-1	Dakota Pearl X Dakota Diamond	0.6	High yield potential, early vine maturity, smaller tuber size profile
NDA081453CAB-2C	Dakota Diamond X ND039173CAB-22	1.0	High yield potential, some resistance to common scab, early vine maturity, high percentage of US #1 tubers, in SNAC and Fast Track 2018
NDTX081648CB-13W	ND8456-1 X ND7377CB-1	2.0	Medium maturity, oval shaped tubers, smaller tuber size profile, in SNAC 2018
NY152 (NYH15-5)	B38-14 X Marcy	1.1	High yield potential, medium specific gravity, excellent long-term storage chip quality, tolerance to common scab, currently in SNAC trial
NY157	White Pearl X Marcy	2.3	High yield potential, low internal defects, medium specific gravity, moderate common scab resistance, in SNAC trial
NY162 (NYK31-4)	NYE106-2 X NYE48-2	0.8	High yield potential, low internal defects, medium specific gravity, moderate common scab resistance, in SNAC and Fast Track 2018
TX09396-1W	Atlantic X Lamoka	1.1	Large tuber size, nice skin, moderate to high yield potential, early vine maturity, in SNAC trial
W8822-1	Fasan X Tundra	0.6	High specific gravity, high yield potential, tolerant to PVY, late maturity, long storage potential, cream to yellow colored flesh depending on environmental conditions
W9968-5	Fasan X Nicolet	0.6	High yield potential, high specific gravity, resistance to common scab, medium vine maturity, in SNAC 2018

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. Common scab data provided from the Potato Outreach Program (POP). Line descriptions provided by potato breeding programs and updated by POP following evaluations at trial locations.

Table 2. 2017 Michigan Statewide Chip Processing Potato Variety Trials
Overall Averages - Sixteen Locations

	CWT/A		PERCENT OF TOTAL[1]							RAW TUBER QUALITY[4] (%)								
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	OTF CHIP SCORE[3]	HH	VD	IBS	BC	COMMON SCAB RATING[5]	SED SCORE[6]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
MSV313-2[di]	713	743	96	2	40	56	2	1.082	1.8	0	20	0	0	0.8	1.8	3.3	3.5	skinning, very large tuber size
MSZ219-13[lp]	596	627	96	2	88	8	2	1.082	1.0	0	12	0	0	0.0	1.0	3.3	3.5	
MSX111-3[l]	530	579	91	7	73	18	2	1.087	1.0	10	20	20	20	0.5	-	3.5	3.0	
W9968-5[bdefgijklp]	526	594	88	10	82	6	2	1.087	1.4	6	11	6	3	0.6	2.8	3.1	3.2	pear shaped, oval to oblong tuber type, heavy russeting
Atlantic[bdip]	**520**	**548**	**95**	**4**	**83**	**12**	**1**	**1.083**	**1.6**	**10**	**13**	**3**	**0**	**1.8**	**2.3**	**3.7**	**3.3**	**alligator hide**
MSX540-4[abeghjklmnop]	511	579	88	10	84	4	2	1.090	1.2	0	12	1	0	0.8	1.1	2.9	3.3	
AF5040-8[dinp]	497	553	88	11	86	2	1	1.084	1.8	0	29	0	0	1.4	1.5	3.7	2.0	large overall tuber size, few b size tubers
NY152[abcdefghklmnop]	496	577	86	12	82	4	2	1.084	1.3	5	13	0	1	1.1	0.7	3.0	2.8	
MSW485-2[abcefghklmop]	495	583	84	14	79	5	2	1.090	1.3	9	12	2	2	0.8	2.6	3.0	3.5	alligator hide
W8822-1[bdik]	494	564	87	11	79	8	2	1.079	1.3	0	8	0	0	0.6	1.5	3.3	2.5	yellow flesh, heavy net skin, pointed pick outs
NY162[klp]	485	530	91	6	83	8	3	1.080	1.1	3	8	4	3	0.8	1.2	3.1	2.0	very bright chip color
Hodag[abcdfghklmnp]	480	539	88	8	76	13	4	1.086	1.0	8	17	2	2	0.5	0.8	3.4	3.1	poined tubers in pickouts
Snowden[abchjklmop]	**478**	**550**	**88**	**10**	**84**	**4**	**2**	**1.088**	**1.2**	**4**	**17**	**4**	**0**	**0.8**	**0.5**	**3.5**	**2.7**	
MSR127-2[abcefghjklmnop]	471	536	87	9	81	7	4	1.088	1.1	3	10	1	0	0.5	1.0	3.3	3.7	alligator hide, some brown center
Mega Chip[k]	466	558	84	5	63	21	11	1.091	1.0	0	20	0	0	0.0	1.5	4.5	2.0	
MSZ052-11[befgjklmp]	463	536	86	7	75	11	7	1.078	1.3	3	11	0	0	0.5	1.2	3.1	3.6	sheep nose, deep apical eyes
NDA081453CAB-2C[bdikop]	463	516	90	7	81	9	3	1.078	1.5	0	16	12	3	1.0	1.7	3.5	2.6	uniform round tuber type
MSV030-4[befgjklmnp]	461	518	89	10	85	4	2	1.090	1.2	0	12	0	0	0.8	1.5	2.9	2.8	slight pink eye, flattened round tuber type, netted skin
Pinnacle Chipper[kp]	455	733	80	20	79	1	0	1.090	1.0	5	25	0	0	0.8	0.8	4.0	2.0	
ND7519-1[bdefgiklp]	452	512	88	10	85	3	2	1.086	1.3	6	10	9	4	1.0	0.9	3.8	2.5	
ND7799C-1[bdijklp]	451	502	89	8	75	14	3	1.066	1.3	3	23	1	0	0.6	1.6	4.0	2.1	skinning, trace alligator hide, heat sprouts
TX09396-1W[bdijklp]	440	480	92	4	55	37	4	1.086	1.0	20	13	22	0	1.1	0.6	2.4	2.8	skinning, knobs and misshapes in pickouts
MSZ022-7[lmp]	437	482	90	6	79	11	3	1.075	1.2	0	15	0	0	0.5	1.5	2.7	4.3	
Lamoka[abefjklmop]	**432**	**501**	**89**	**7**	**84**	**5**	**4**	**1.085**	**1.4**	**2**	**15**	**1**	**1**	**1.0**	**1.1**	**3.5**	**2.6**	**flattened oval tuber type, chip blistering**
MSZ219-1[lp]	432	460	95	3	78	17	2	1.081	1.0	7	7	0	0	0.3	-	3.7	3.5	
Manistee[abchjklmp]	427	470	89	9	82	7	1	1.081	1.1	0	5	0	0	0.9	0.6	3.4	2.6	flat round tuber type, nice netted skin type
AF4648-2[bdiklp]	422	480	87	9	82	5	4	1.081	1.2	4	10	2	0	0.6	1.3	3.6	2.8	slight bruising, oval tuber type, bright appearance
MSZ219-14[lp]	407	439	93	4	86	7	3	1.080	1.5	0	25	0	5	0.3	0.5	3.7	3.5	
NY157[bcj]	398	460	87	12	81	6	1	1.083	1.0	25	0	0	5	2.3	0.5	2.0	2.5	
MSV358-3[abefgklmnop]	390	438	89	9	85	4	3	1.079	1.4	1	10	0	0	0.8	0.9	2.8	2.3	very nice chip color and quality
MSZ242-9[l]	351	458	76	19	72	4	5	1.094	1.0	0	10	20	0	0.0	-	4.0	3.0	
Pike[bkm]	**339**	**401**	**84**	**13**	**75**	**9**	**3**	**1.082**	**1.0**	**0**	**7**	**30**	**10**	**0.2**	**0.3**	**2.8**	**2.7**	
Saginaw Chipper[kp]	338	426	80	20	79	1	0	1.079	1.3	0	40	0	0	0.3	0.8	5.0	2.5	
MSX120-5Y[m]	336	437	77	19	75	2	4	1.078	1.0	0	0	0	0	0.5	-	2.5	4.0	severe pink eye, light yellow flesh
Madison[bklp]	327	392	83	12	80	3	5	1.097	1.5	10	6	3	0	0.6	0.7	3.4	1.8	
NDTX081648CB-13W[o]	320	405	79	19	78	1	2	1.083	3.0	0	40	0	0	2.0	-	1.5	3.0	
MSV016-2[m]	299	322	93	5	63	30	2	1.089	2.5	30	0	0	0	0.0	-	1.5	3.5	smooth light skin
MSV033-1[m]	297	437	68	4	49	19	28	1.084	1.0	60	0	0	0	1.0	-	2.5	4.0	many misshapen tubers, sheep nose, knobs
B2727-2[o]	262	294	89	6	82	7	5	1.081	3.0	10	17	0	0	2.7	-	0.5	3.5	oval tuber type
MSX050-1[m]	249	352	70	17	64	6	13	1.065	1.5	10	0	0	0	0.5	-	3.5	4.0	
MSV307-2[m]	241	352	68	16	59	9	16	1.079	1.0	30	0	0	0	0.5	-	3.0	3.0	many misshapen tubers, growth crack
MSZ242-13[l]	240	313	77	20	77	0	3	1.100	1.0	0	0	0	0	0.0	-	3.5	3.0	
MSZ219-46[l]	234	246	95	5	73	22	0	1.079	1.0	0	20	0	0	0.5	-	4.0	3.5	
AC01144-1W[o]	222	318	71	23	68	3	6	1.067	4.0	3	43	0	0	1.3	-	2.0	3.0	some black leg
MSW075-2[l]	125	197	64	35	64	0	1	1.078	1.0	0	0	0	0	0.0	-	3.5	3.0	
MEAN	**440**	**507**	**87**	**9**	**77**	**10**	**4**	**1.084**	**1.3**	**6**	**14**	**4**	**1**	**0.8**	**1.2**	**3.2**	**2.9**	

2017 Chip Variety Trial Sites

[a]4-L Farms, Allegan County
[b]County Line Farms, Allegan County
[c]Crawford Farms, Montcalm County
[d]Crooks Farms Set #1, Montcalm County
[e]Crooks Farms Set #2, Montcalm County
[f]Crooks Farms Set #3, Montcalm County
[g]Crooks Farms Set #4, Montcalm County
[h]Johnsons Farms, Bay County
[i]Lennard Ag. Company Early Trial, St. Joseph County, MI
[j]Lennard Ag. Company Chip Trial, St. Joseph County, MI
[k]Main Farms, Montcalm County
[l]MSU Box Bin Trial, Montcalm County
[m]MSU Late Box Bin Trial, Montcalm County
[n]Sandyland Farms, Montcalm County
[o]Sandyland Farms SNAC Trial, Montcalm County
[p]Walther Farms, St. Joseph County

[1]SIZE

Bs: < 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts

[2]SPECIFIC GRAVITY

Data not replicated within trials

[3]OUT OF THE FIELD CHIP COLOR SCORE

(SNAC Scale)
Ratings: 1 - 5
1: Excellent
5: Poor

[4]RAW TUBER QUALITY

(percent of tubers out of 10)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[5]COMMON SCAB RATING

0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

[6] SED(STEM END DEFECT) SCORE

0: No stem end defect
1: Trace stem end defect
2: Slight stem end defect
3: Moderate stem end defect
4: Severe stem end defect
5: Extreme stem end defect

[7]VINE VIGOR RATING

Date: variable
Rating 1-5
1: Slow emergence
5: Early emergence

[8]VINE MATURITY RATING

Date: variable
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

Table 3. Yield, Size Distribution,* and Specific Gravity for the 2017 SNAC Trial at Sandyland Farms								
	Yield (cwt/A)		Percent Size Distribution					
Entry	US#1	TOTAL	US#1	Small	Mid-Size	Large	Culls	Specific Gravity
MSX540-4	500^{a}	570	88	9	86	2	3	1.087
MSW485-2	495^{a}	575	86	13	83	3	1	1.086
Snowden	**493^{a}**	**570**	**87**	**11**	**84**	**3**	**2**	**1.085**
MSR127-2	469^{ab}	523	90	5	85	5	5	1.086
NY152	461^{abc}	551	84	12	82	2	4	1.080
Lamoka	**419^{bcd}**	**489**	**87**	**10**	**84**	**3**	**3**	**1.082**
MSV358-3	396^{cd}	477	83	12	79	4	5	1.074
NDA081453CAB-2C	388^{de}	450	88	10	84	4	2	1.079
NDTX081648CB-13W	320^{ef}	405	79	19	78	1	2	1.083
AF5040-8	276^{fg}	375	76	22	72	4	2	1.081
B2727-2	262^{gh}	294	89	6	82	7	5	1.081
AC01144-1W	222^{h}	318	71	23	68	3	6	1.067
MEAN	**392**	**467**	**84**	**13**	**81**	**3**	**3**	**1.081**
ANOVA p-value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.2216	0.0552	**<0.0001**
LSD	**60.3**	**63.3**	**5.9**	**3.8**	**5.9**	-	-	**0.002**

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

Entries are ranked by US#1 yield

Table 4. At-Harvest Tuber Quality for the 2017 SNAC Trial at Sandyland Farms				
	Raw Tuber Quality[1] (%)			
Entry	HH	VD	IBS	BC
MSX540-4	0	10	0	0
MSW485-2	3	37	0	0
Snowden	**0**	**47**	**0**	**0**
MSR127-2	3	33	0	0
NY152	0	37	0	0
Lamoka	**0**	**30**	**0**	**0**
MSV358-3	0	40	0	0
NDA081453CAB-2C	0	33	0	0
NDTX081648CB-13W	0	40	0	0
AF5040-8	0	47	0	0
B2727-2	10	17	0	0
AC01144-1W	3	43	0	0
MEAN	**2**	**35**	**0**	**0**
ANOVA p-value	0.2710	**<0.0001**	-	-
LSD	-	**13.5**	-	-

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

Entries are ranked by US#1 yield

Table 5. Post-Harvest Chip Quality[1] for the 2017 SNAC Trial at Sandyland Farms						
	Agtron	SFA[2]	Specific	Percent Chip Defects[3]		
Entry	Color	Color	Gravity	Internal	External	Total
NY152	63.2	2.0	1.084	11.4	7.6	19.0
Lamoka	**59.0**	**2.0**	**1.081**	**19.6**	**3.2**	**22.8**
MSX540-4	61.3	3.0	1.084	6.5	4.5	11.0
MSV358-3	60.6	2.0	1.071	3.2	15.9	19.1
MSW485-2	57.5	3.0	1.080	16.8	6.6	23.4
NDTX081648CB-13W	60.8	3.0	1.084	7.1	0.5	7.6
Snowden	**59.8**	**3.0**	**1.078**	**11.5**	**14.9**	**26.4**
NDA081453CAB-2C	59.3	3.0	1.075	7.3	1.5	8.8
B2727-2	57.3	3.0	1.076	21.1	29.8	50.9
AF5040-8	60.4	3.0	1.081	7.2	31.1	38.3
MSR127-2	55.7	3.0	1.087	33.4	4.2	37.6
AC01144-1W	57.1	4.0	1.067	19.0	10.0	29.0

[1] Samples collected October 17th and processed by Herr Foods, Inc., Nottingham, PA on October 23th, 2017.

Chip defects are included in Agtron and SNAC 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.

Lines are sorted by Herr's ratings, with the higest ranking line at the top of the table

Table 6. Black Spot Bruise Test for the 2017 SNAC Trial at Sandyland Farms																			
	A. Check Samples[1]									B. Simulated Bruise Samples[2]									
	# of Bruises Per Tuber						Total	Percent Bruise	Average Bruises Per	# of Bruises Per Tuber						Total	Percent Bruise	Average Bruises Per
Entry	0	1	2	3	4	5	Tubers	Free	Tuber	0	1	2	3	4	5	Tubers	Free	Tuber
MSV358-3	19	3	3	0	0	0	25	76	0.4	18	6	1	0	0	0	25	72	0.3
NDTX0981648CB-13W	15	9	0	0	0	0	24	63	0.4	17	8	0	0	0	0	25	68	0.3
NY152	15	10	0	0	0	0	25	60	0.4	17	6	2	0	0	0	25	68	0.4
AC01144-1W	21	4	0	0	0	0	25	84	0.2	15	5	2	1	0	0	23	65	0.5
NDA081453CAB-2C	21	3	1	0	0	0	25	84	0.2	15	8	1	1	0	0	25	60	0.5
AF5040-8	17	8	2	0	0	0	27	63	0.4	16	5	2	2	0	0	25	64	0.6
Lamoka	**14**	**10**	**1**	**0**	**0**	**0**	**25**	**56**	**0.5**	**13**	**7**	**5**	**0**	**0**	**0**	**25**	**52**	**0.7**
MSW485-2	18	5	2	0	0	0	25	72	0.4	11	9	3	2	0	0	25	44	0.8
MSR127-1	13	7	5	0	0	0	25	52	0.7	7	14	2	1	1	0	25	28	1.0
Snowden	**14**	**9**	**2**	**0**	**0**	**0**	**25**	**56**	**0.5**	**6**	**8**	**7**	**4**	**0**	**0**	**25**	**24**	**1.4**
B2727-2	17	5	3	0	0	0	25	68	0.4	2	13	5	4	1	0	25	8	1.6
MSX540-4	12	11	2	0	0	0	25	48	0.6	5	3	8	5	2	1	24	21	2.0

[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 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 Panel for the 2017 SNAC Trial at Sandyland Farms, Taken on 8/17/2017								
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Number of Hills	Number of Stems	Average[5] Tuber Weight
MSX540-4	1.083	0.013	0.804	100	100	3	13	2.58
MSW485-2	1.076	0.006	1.853	100	100	3	10	1.79
Snowden	**1.082**	**0.004**	**0.415**	**100**	**100**	**2**	**13**	**2.97**
MSR127-2	1.071	0.023	1.122	100	100	3	11	2.52
NY152	1.082	0.005	0.129	100	100	3	10	2.70
Lamoka	**1.078**	**0.003**	**0.656**	**100**	**100**	**3**	**14**	**2.29**
MSV358-3	1.077	0.004	0.462	100	100	3	9	3.21
NDA081453CAB-2C	1.073	0.003	1.073	100	100	4	17	2.73
NDTX081648CB-13W	1.075	0.013	0.660	100	100	3	23	1.89
AF5040-8	1.076	0.007	1.279	100	100	3	16	2.20
B2727-2	1.081	0.003	1.217	100	100	5	13	3.90
AC01144-1W	1.062	0.041	0.720	100	100	4	17	1.71

Table 7B. Pre-Harvest Panel for the 2017 SNAC Trial at Sandyland Farms, Taken on 8/30/2017								
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Number of Hills	Number of Stems	Average[5] Tuber Weight
MSX540-4	1.085	0.003	0.505	100	100	4	16	4.45
MSW485-2	1.080	0.004	2.193	100	100	3	8	2.92
Snowden	1.083	0.002	0.505	100	100	3	16	3.50
MSR127-2	1.080	0.004	1.501	100	100	3	14	3.57
NY152	1.076	0.002	0.23	100	100	2	10	3.40
Lamoka	1.080	0.002	0.832	75	75	5	15	3.52
MSV358-3	**1.070**	**0.001**	**0.529**	**100**	**100**	**3**	**13**	**2.78**
NDA081453CAB-2C	**1.075**	**0.002**	**1.021**	**100**	**100**	**3**	**13**	**4.43**
NDTX081648CB-13W	1.073	0.005	0.791	100	100	3	16	2.05
AF5040-8	1.072	0.001	0.587	100	100	3	12	2.17
B2727-2	1.079	0.002	0.649	100	100	4	9	4.60
AC01144-1W	1.066	0.018	0.46	100	100	3	12	2.42

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

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

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

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

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

Table 8.Variety Information for 2017 MSU Tablestock Potato Variety Trials

Russet Variety Descriptions

Entry	**Pedigree**	**2017 Scab Rating***	**Characteristics**
Caribou Russet (AF3362-1Rus)	Reeves Kingpin X Silverton Russet	0.3	Long russet with excellent yield, processing potential and good appearance, common scab tolerance, early bulking potential, medium russet skin, tolerant to Sencor & Linuron, some internal browning from heat stress observed in 2015, PVY susceptible, below average tuber set
GoldRush Russet (ND1538-1Rus)	ND450-3Rus X Lemhi Russet	0.1	Medium maturity, oblong-blocky to long tubers, bright white flesh, common scab resistance, average yield potential
Payette Russet (A02507-2LB)	EGA09702-2 X GemStar Russet	0.4	High yield potential, high specific gravity, late blight and PVY resistance, late maturing
Russet Norkotah (ND534-4Rus)	ND9526-4Rus X ND9687-5Rus	0.5	Average yield, mid-season maturity, long to oblong tubers, heavy russet skin, low specific gravity
Reveille Russet (ATX91137-1Rus)	Bannock Russet X A83343-12	0.6	Excellent yield potential, common scab tolerant, early bulking, nice uniform dark russeted skin with good general tuber appearance, occasional misshaped tubers observed
Silverton Russet (AC83064-6)	A76147-2 X A7875-5	0.4	High yield, oblong to long blocky tuber type, medium netted russet skin, masks PVY, medium specific gravity, PVY, Sencor & Linuron susceptibility
A06021-1TRUS	A99031-1TE X A96013-2	0.5	Medium yield potential, prominent lenticels, common scab tolerance, nice blocky tuber type, light to medium russet skin
A06030-23RUS	Premier Russet X A99133-6	0.4	Average to high yield potential, resistance to common scab, early to medium vine maturity
A07061-6RUS	Clearwater Russet X Targhee Russet	1.3	High yield potential, resistant to internal defects and common scab
A08433-4VRRUS	Dakota Trailblazer X A01667-3	0.7	High yield potential, larger tuber size profile, resistance to common scab

(2017 Russet Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
AF5091-8RUS	AF4116-9 X AF4185-1	0.3	A mid-season russet with better marketable yields than Russet Burbank in Maine trials, long to oblong tubers that tend to be large, resistance to blackspot bruise
AF5179-4RUS	A01601-4 X Highland Russet	2.0	A medium-late maturing russet with better marketable yields than Russet Burbank in Maine trials, long to oblong tubers that tend to be large, resistance to verticillium wilt
AF5312-1RUS	A86102-6 X CO82142-4	0.2	Average yield potential, resistant to internal defects, attractive tuber type, darker skin
AF5468-5RUS	NY132 X Liberator	0.2	Average yield potential, resistance to common scab
CO05175-1RUS	Mesa Russet X AC96052-1RU	0.0	High yield potential, medium specific gravity, long tubers, medium vine maturity, resistant to blackspot bruise, processing potential
CW08221-5RUS	CO98067-7RUS X A99073-1RUS	0.2	Early vine maturity, heavy skin russeting
ND050032-4RUS	Dakota Russet X Dakota Trailblazer	0.3	High yield potential, large size profile, medium maturity, light russeted skin with blocky tuber shape
TX08352-5RUS	TXA549-1Ru X AOTX98137-1Ru	0.3	Nice slightly blocky shape, larger size profile, medium vine vigor and maturity, semi-erect vines
W10594-16RUS	Premier Russet X Freedom Russet	0.8	High specific gravity, resistance to internal defects, medium vine maturity
W10612-8RUS	W6360-1RUS X Russet Norkotah	0.7	High yield potential, resistance to internal defects and common scab
W9433-1RUS	CalWhite X A96023-6RUS	0.5	Light russet skin type, high yield potential, tolerance to verticillium wilt and early blight, medium-late maturity, oblong to blocky tubers
W9742-3RUS	A99134-1 X Dakota Trailblazer	0.6	Medium-late maturity, high specific gravity, pear shaped tubers

(2017 Russet Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
WAF10073-3RUS	Freedom Russet X Alpine Russet	0.5	Resistance to internal defects, medium vine maturity
WND8625-2RUS	W2699-1RUS X Silverton Russet	0.7	Medium maturity, average yield potential, dual-purpose tubers, high specific gravity, good storability with low sugar accumulation

Yellow Flesh Variety Descriptions

Entry	Pedigree	2017 Scab Rating*	Characteristics
Alegria	Norika America, LLC	0.7	High yield potential, long-oval tuber shape, resistant to Ro1 Ro4 cyst nematodes, PVY, and leaf roll
Allora	Norika America, LLC	1.4	High yield potential, oval-oblong tuber shape, light to medium yellow flesh, early to medium maturity, resistant to Ro1 cyst nematodes, PVY, and leaf roll
Annabelle	Nicola X Monalisa	1.5	Early maturity, long oval tubers, bright yellow skin with creamy yellow flesh, short dormancy
Butterfly	VDW 90-50 X RZD 88-1036	0.0	Dark yellow flesh, good internal quality, 60% B size tubers in 2017, some sticky stolons
Elfe	Sun Rain	0.7	High yield potential, smooth light yellow skin with medium yellow flesh, early season maturity, resistant to common scab, blackleg, and Rhizoctonia
Jelly	Sun Rain	0.7	High yield potential, oblong tubers, medium yellow flesh, medium to late maturity, resistant to common scab, PVY, Rhizoctonia, blackleg, and late blight
Juliette	Nicola X Hansa	0.0	B sized potato, very high specific gravity, full season maturity, acceptable internal quality

(2017 Yellow Flesh Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
Julinka	Sun Rain	1.0	High yield potential, yellow skin with bright yellow flesh, oval tuber shape, early season maturity, resistant to common scab
Lady Alba	-	0.5	Smaller tuber size profile, early vine maturity, common scab resistance
Malou	Oasis X INRA94T146.43	1.1	Oval shape, medium yellow flesh, small size profile
Lady Anna	CMK1993-042-005 X Fontane	1.5	Light yellow skin with yellow flesh, oblong shape, uniform, medium maturity, resistant to bruising and common scab, ideal for french fries
Montreal	Solanum International	1.4	Round to oval in shape, light yellow skin with light yellow flesh, shallow eyes, large tuber size, high yield potential, resistance to tuber blight, medium
Musica	Meijer Seed Potato Ltd.	0.6	Deep yellow flesh with light yellow skin, mid-early maturity, resistance to PVY and several potato cyst nematodes
Oneida Gold (W6703-1Y)	Satina X W2275-2Y	0.8	Good yield, medium maturity, slightly better shape than W6703-5Y, common scab tolerant, medium yellow flesh, buff to slightly netted skin type
Queen Anne	Solanum International	0.6	Oval to oblong shape, yellow flesh, yellow skin, shallow eyes, medium to high scab resistance, PVY resistance and resistance to Ro1 and Ro4 nematodes
Smart	HZPC	1.0	Early to medium variety, deep yellow, high number of tubers per plant, round to oval shape, deep yellow skin and flesh, resistant to Potato Cyst Nematodes, medium resistance to common scab
Soraya	Norika America, LLC	0.6	High yield potential, late maturity, large oval-oblong tubers with yellow skin and yellow flesh, low specific gravity, resistant to common and powdery scab
Viviana	Sun Rain	1.7	High yield potential, smooth yellow skin with light yellow flesh, oval tuber shape, early season maturity, tolerant to common scab, black leg, and late blight

(2017 Yellow Flesh Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
Wega	Norika America, LLC	0.6	High yield potential, medium yellow flesh, oval-oblong tuber shape, resistant to PVY and Ro1 Cyst nematodes
Wendy	Norika America, LLC	1.1	Yellow skin and flesh, oval shape, resistant to Ro1 and Ro4 nematodes, resistant to common scab, moderate resistance to leaf and tuber blight
Yukon Gold	Norgleam X W5279-4	1.5	Moderate yields, medium maturity, oval shaped with yellow-white skin and light yellow flesh, common scab susceptible
CMK 2005-010-027	Meijer Seed Potato Ltd.	1.0	B sized tuber profile, early vine maturity
CMK 2006-070-005	Meijer Seed Potato Ltd.	1.0	Early season variety, light yellow flesh, high yield potential
NY149	Yukon Gold X Keuka Gold	0.9	Mid to late season, slightly-textured skin and pink eyes, oval shape, medium yellow flesh, resistance to Ro1 cyst nematode, moderate common scab resistance
NY161	Daisy Gold X C24-1	0.9	Yellow flesh, high yield potential, acceptable internal quality, purple splashes on eyes
W10564-19Y	W9979-2YR/Y X Gala	0.5	Medium vine maturity, common scab resistance
W9576-11Y	Dakota Pearl X Gala	1.5	Medium maturity, high yield potential, buff skin type, nice yellow flesh color

Red Skin Variety Descriptions

Entry	Pedigree	2017 Scab Rating*	Characteristics
Cerata	Stet Holland	0.8	Medium to late maturity, oval shaped tubers, white flesh and dark red skin, adapted to all soil types, suitable for storage, resistant to potato cyst nematodes Ro1, moderate resistance to common scab

(2017 Red Skin Varieties Cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
6049	-	0.0	Good internal quality, common scab resistance, early vine maturity, some alligator hide
Dakota Ruby	ND7188-4R X ND5256-7R	1.3	Uniform round, smooth tubers with white flesh, vigorous vine, nice dark red skin, some possible issues with skin set
Dark Red Chieftain	LA1354 X LA1027-18	0.7	Broadly adapted, high yield potential, medium maturity, oblong to round tubers, moderate resistance to common scab
Dark Red Norland	Redkote X ND626	0.6	Broadly adapted, low to moderate yields, early season maturity, smooth, oblong, slightly flattened tubers, common scab tolerant
Lollipop	Solanum International	1.0	Small round tubers, with shallow eyes, medium resistance to PVY, foliage blight, tuber blight, average yield
Modoc	ND1196-2R X ND2225-1R	0.3	Average yield potential, smaller size profile, early maturity, round to oval tubers, susceptible to late blight
Red Endeavor	B1491-5 X W1100R	1.4	Uniform round tubers with shallow eyes, skin color similar to Dark Red Norland, skin set comparable to Red LaSoda
AF4831-2R	ND028946B X ND8555-8R	1.2	A mid-season, bright red-skinned, white-fleshed variety with oblong tubers and small size profile, moderate common scab and verticillium resistance
MSW343-2R	MSQ440-2 X NDTX4172-5R	0.3	Early bulking red skin potato with some scab tolerance
MSX569-1R	MSS002-2R X MSS544-1R	1.3	Good internal quality, small vine type, very early maturity
ND6002-1R	NorDonna X Bison	1.6	Uniform tubers, bright red skin, good yield potential, medium vine maturity, average specific gravity, common scab susceptible
ND7132-1R	ND5002-3R X ND5438-1R	1.6	Medium maturity and yield potential, bright red skin with white flesh, oval to oblong shape, common scab susceptible

(2017 Red Skin Varieties cont.)

Entry	Pedigree	2017 Scab Rating*	Characteristics
W8405-1R	Kankan X W2303-9R	1.0	Oval tuber type
W8890-1R	W2169-1R X Dakota Rose	0.9	Fresh market, dark red skin color and smaller size profile

Round White Variety Descriptions

Entry	Pedigree	2017 Scab Rating*	Characteristics
Onaway	USDAX96-56 X Katahdin	1.5	Early maturity, low specific gravity, used primarily out-of-the field for fresh market, minimal internal defects, not recommended for storage
Reba (NY 87)	Monona X Allegany	0.8	High yield, bright tuber appearance, low incidence of internal defects, mid to late season maturity, medium specific gravity, resistance to golden nematode Ro1, common scab, verticillium wilt, and early blight, susceptible to late blight and PVY
AF4138-8	SA9707-6 X AF1953-4	0.8	High yield potential, low incidence of HH and external defects, early to mid-season maturity, moderate scab resistance, blackspot resistance, small size profile
MSU161-1	MSM182-1 X MSL211-3	1.5	Above average yield potential, medium vine maturity, round, uniform tubers with netted skin, resistance to common scab
MSU383-A	MSP292-7 X MSG227-2	0.5	Average/high yield potential, common scab resistant, average specific gravity
MSV179-1	Liberator X MSL211-3	0.6	Average yield, round white potato with bright skin, scab resistance
MSX497-6	MSQ131-A X MSL268-D	0.9	Bright skin appearance, uniform round tuber type
MSY111-1	MSQ086-3 X McBride	0.7	High yield potential, good internal quality, common scab resistance
NY157	White Pearl X NY 115	0.8	High yield potential, low internal defects, medium specific gravity, moderate common scab resistance, chipping potential

Novelty Variety Descriptions

Entry	Pedigree	2017 Scab Rating*	Characteristics
AmaRosa	PA97B23-2 X Red Bulk Pollen	1.5	Red skin and red flesh, mid-season maturity, "russet-shaped" tubers, resistant to common scab and late blight, retains color after cooking and chipping
AF5245-1P	Michigan Purple X Villeta Rose	0.6	High yield potential, acceptable internal quality, Common Scab resistance, early maturity
AF5414-1RR	BC001044-2 X Dakota Jewel	1.0	Some purple flesh, high proportion of A sized tubers, medium vine maturity
CO08155-2RU/Y	Fortress Russet X Innovator	0.6	Yellow or cream-colored flesh, pink eyes, good internal quality.
MSX324-1P	MSN105-1 X Colonial Purple	0.4	Attractive purple skin with white flesh, some scab tolerance
MSZ109-5RR	COMN07-W11BG1 X MSU200-5PP	0.0	Very small tubers, 100% B size in 2017, good internal quality, very early vine maturity
NY161	Daisy Gold X C2401	0.9	Yellow flesh, purple splashed eyes, full season variety

* Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. Common scab data provided by Potato Outreach Program. Line descriptions provided by potato breeding programs and updated by Potato Outreach Program following evaluations at trial locations throughout Michigan.

Table 9. 2017 Michigan Statewide Russet Potato Variety Trials
Overall Averages - Twelve Locations

	CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
W9433-1RUS[g]	678	878	77	2	24	53	21	1.088	20	0	60	0	0.5	2.5	3.0	
Caribou Russet[del]	558	602	93	5	68	24	2	1.078	3	40	3	3	0.3	4.0	3.3	medium russeted skin type
A08433-4VRRUS[cij]	557	663	83	10	59	24	6	1.080	0	27	0	0	0.7	3.0	4.3	
A07061-6RUS[bfgijk]	513	670	76	17	68	8	7	1.080	0	3	0	0	1.3	3.1	3.9	
Silverton Russet[bcfghijkl]	**500**	**579**	**86**	**9**	**66**	**20**	**5**	**1.071**	**1**	**6**	**1**	**1**	**0.4**	**3.2**	**3.6**	
Russet Norkotah[bcefgikhjl]	**487**	**590**	**82**	**11**	**60**	**22**	**7**	**1.078**	**18**	**7**	**2**	**0**	**0.5**	**3.3**	**2.6**	
COTX09022-3RURE/Y[bfgl]	483	593	81	13	73	8	7	1.084	5	8	5	0	1.4	3.1	3.3	pink eye splashes
AF5179-4RUS[bcfgijkl]	468	583	81	6	53	28	13	1.089	0	9	4	0	2.0	2.4	3.8	tubular shape
W10612-8RUS[j]	449	543	83	8	72	11	9	1.079	0	0	0	0	0.7	2.3	3.7	
A06021-1TRUS[bfgijk]	445	530	84	10	62	21	6	1.076	7	5	2	0	0.5	2.5	3.0	
ND50032-4RUS[bcfghijkl]	444	549	81	8	56	25	11	1.082	13	17	2	0	0.3	2.6	3.1	alligator hide, some net skin, skin not uniform, growth cracks
Reveille Russet[bcdefgjkhl]	435	535	80	10	58	22	10	1.071	1	13	0	0	0.6	2.7	2.9	uniform russeted skin, growth crack in pickouts
W10594-16RUS[ij]	432	579	75	16	67	8	9	1.081	0	0	0	0	0.8	2.3	3.6	
WND8625-2RUS[bcfghjkl]	427	502	85	10	63	22	6	1.075	22	5	0	1	0.7	2.7	3.3	growth crack in pickouts
AF5091-8RUS[cij]	413	557	75	9	53	22	16	1.071	0	13	0	0	0.3	2.8	2.7	
AF5312-1RUS[bcdfgjkl]	413	547	74	19	65	9	7	1.071	1	3	0	0	0.2	3.0	2.8	good shape, nice dark russet skin, heat knobs
W9742-3RUS[bcdfghijkl]	411	483	85	6	60	25	9	1.093	3	5	1	0	0.6	2.6	3.2	some alligator hide, light russet skin type, growth cracks
AF5468-5RUS[cjl]	407	508	79	15	64	15	6	1.071	3	13	0	0	0.2	2.9	3.7	
TX08352-5RUS[bcdfghijkl]	401	496	80	15	68	12	5	1.064	7	5	1	0	0.3	2.4	2.7	uniform dark russeted skin type, some greening
GoldRush[cefl]	**365**	**462**	**79**	**15**	**72**	**7**	**6**	**1.076**	**3**	**25**	**0**	**0**	**0.1**	**3.6**	**2.5**	
Payette Russet[bcdefghijkl]	340	450	76	10	60	14	16	1.086	5	8	0	0	0.4	1.5	3.7	some alligator hide, type not uniform, dark russeted skin
WAF10073-3RUS[bcdfgjk]	338	503	66	21	55	11	13	1.070	0	0	0	0	0.5	2.6	3.0	some alligator hide, poor tuber shape
CW08221-5RUS[abcfghjkl]	324	436	69	22	60	9	9	1.061	11	6	3	0	0.2	2.7	3.1	heavy russeted skin
A06030-23RUS[bfgijk]	316	435	70	18	54	16	12	1.081	13	7	1	0	0.4	2.1	2.8	alligator hide, severe growth crack in pickouts, pointed
CO05175-1RUS[f]	288	383	72	18	72	0	10	1.080	30	30	0	0	0.0	3.0	4.5	
MEAN	**442**	**553**	**79**	**12**	**61**	**18**	**9**	**1.077**	**6**	**9**	**4**	**0**	**0.6**	**2.8**	**3.2**	

2017 Russet Variety Trial Sites
[a]4-L Farms, Allegan County
[b]Crawford Farms, Montcalm County
[c]Elmaple Farms, Kalkaska County
[d]Horkey Brothers, Monroe County
[e]Jenkins Farms, Kalkaska County
[f]Kitchen Farms, Antrim County
gLennard Ag. Company, St. Joseph County, MI
[h]TJJ Farms, Delta County
[i]Walther Farms NFPT Trial Selected Varieties, St. Joseph County
[j]Walther Farms Russet Norkotah Trial, St. Joseph County
[k]Walther Farms Silverton Russet Trial, St. Joseph County
[l]Wilk's Farms, Presque Isle County,

[1]SIZE
Russets
Bs: < 4 oz
As: 4 - 10 oz
OV: > 10 oz
PO: Pickouts

[2]SPECIFIC GRAVITY
Data not replicated

[3]RAW TUBER QUALITY
(percent of tubers out of 10)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[4]COMMON SCAB RATING
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

[5]VINE VIGOR RATING
Date: variable
Rating 1-5
1: Slow emergence
5: Early emergence

[6]VINE MATURITY RATING
Date: variable
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

Table 10. 2017 Michigan Statewide Tablestock Potato Variety Trials
Overall Averages - Nine Locations

		CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							
	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
	Soraya[abcdefg]	494	600	81	11	78	3	8	1.060	0	8	0	1	0.6	3.6	3.6	good tubertype
	Jelly[bcdefghi]	468	546	82	13	81	3	3	1.078	3	27	0	0	0.7	3.5	4.1	oval to oblong tuber shape
	Musica[bcdefghi]	455	623	71	24	70	1	5	1.068	1	6	9	0	0.6	3.8	3.1	trace heat sprouts
	Malou[bcdeghi]	449	581	76	22	73	2	3	1.063	0	21	1	0	1.1	4.1	3.0	bright skin color
	NY161[beghi]	446	563	76	21	74	2	3	1.074	4	7	2	0	0.9	3.3	3.5	eyes splashed purple
	Alegria[bcdefghi]	427	495	85	11	74	10	5	1.078	4	19	3	6	0.7	3.7	3.1	oblong tuber type, pink eyes, greening
	Yukon Gold[bdefghi]	**406**	**466**	85	**8**	**76**	**9**	**7**	**1.080**	**2**	**7**	**0**	**1**	**1.5**	**3.7**	**2.9**	**pink eyes**
	Elfe[bcdefghi]	380	492	76	17	74	2	7	1.067	1	16	0	1	0.7	3.8	2.6	heat sprouts
	Montreal[bcdefghi]	379	473	80	15	73	6	6	1.071	0	23	3	5	1.4	4.2	2.8	
	Oneida Gold[abei]	377	437	79	13	81	5	1	1.070	0	15	0	0	0.8	3.4	3.7	inconsistent flesh color
	Viviana[bceghi]	369	509	71	25	70	1	4	1.062	0	7	0	7	1.7	3.9	2.4	
	Allora[bcdefghi]	368	442	81	13	78	4	5	1.069	0	12	0	0	1.4	2.9	2.5	
YELLOW SKIN TYPE	Wendy[bdeghi]	367	577	61	36	61	1	2	1.063	0	5	0	0	1.1	3.3	3.6	
	NY149[fbceghi]	360	441	80	15	78	4	4	1.075	1	16	2	0	0.9	3.3	3.2	pink eyes, sticky stolons
	W9576-11Y[bcdefi]	355	452	78	20	77	2	2	1.058	1	17	0	0	0.3	3.6	2.2	some alligator hide, netted skin
	Julinka[bcegh]	349	512	65	28	66	1	5	1.065	0	24	0	0	1.0	3.6	2.8	
	Wega[abcdefghi]	333	529	61	34	59	2	6	1.063	0	18	2	0	0.6	3.3	3.4	some glassy ends
	Queen Anne[bcdefghi]	322	463	68	27	65	4	5	1.060	0	14	3	0	0.6	2.8	2.9	bright waxy appearance
	Lady Alba[h]	247	479	52	46	52	0	2	1.078	0	0	0	20	0.5	5.0	2.5	
	CMK 2006-070-005[gh]	244	386	63	32	61	3	5	1.058	5	17	0	0	1.0	4.5	2.0	
	Smart[a]	154	306	50	49	50	0	1	1.059	0	0	0	0	1.0	3.5	3.5	
	W10564-19Y[e]	151	636	24	11	22	2	0	1.069	0	40	0	0	0.5	4.0	3.5	
	Butterfly[a]	110	278	39	61	39	0	0	1.057	0	0	10	0	0.0	3.0	4.0	some sticky stolons
	Lady Anna[gh]	103	296	34	63	34	0	4	1.076	0	10	0	0	1.5	5.0	2.5	oblong tuber type
	Annabelle[a]	76	256	30	69	30	0	1	1.054	0	0	0	0	1.5	2.5	4.0	
	CMK 2005-010-027[gh]	68	303	26	74	26	0	1	1.063	0	22	10	0	1.0	4.5	2.0	
	Juliette[a]	1	217	0	98	0	0	2	1.101	0	20	0	0	0.0	2.0	4.5	
	MEAN	**318**	**467**	**64**	**29**	**62**	**2**	**4**	**1.067**	**1**	**13**	**2**	**2**	**0.9**	**3.7**	**3.1**	
	Cerata[bcdefghi]	535	622	85	13	83	2	2	1.073	0	10	0	0	0.8	4.1	3.8	slight heat sprouts
	W8405-1R[befghi]	442	547	72	23	66	7	5	1.064	0	11	8	3	1.0	3.4	3.0	oval tuber type
	ND7132-1R[bcefgi]	439	516	84	9	73	11	7	1.062	1	14	4	0	1.6	3.6	3.1	slight skinning, sticky stolons
	Red Endevor[bfghi]	415	514	79	19	72	7	2	1.063	2	11	0	0	1.4	3.7	2.5	sticky stolons
	MSW343-2R[bei]	406	477	85	10	78	8	5	1.054	0	7	0	0	0.3	2.8	3.0	sheep nose, deep eyes
	Dark Red Chieftain[cdefghi]	388	424	91	7	79	11	2	1.066	6	14	0	0	0.7	3.1	2.7	sticky stolons
	Dakota Ruby[abcdefghi]	374	477	76	19	77	1	4	1.069	2	9	0	0	1.3	3.4	2.5	uniform skin type, some skinning
RED SKIN TYPE	AF4831-2R[abcdefgi]	370	491	72	25	72	0	3	1.065	0	6	4	0	1.2	3.1	2.8	Rhizoctonia, some skinning
	W8890-1R[abcefgi]	345	419	80	17	78	3	2	1.066	3	35	1	1	0.9	3.1	3.1	uniform tuber type
	Dark Red Norland[befghi]	**344**	**414**	**83**	**12**	**80**	**3**	**4**	**1.063**	**0**	**5**	**0**	**0**	**0.6**	**4.0**	**2.4**	
	Fenway[a]	330	416	79	21	79	0	0	1.059	0	0	0	0	0.5	4.0	3.0	
	ND6002-1R[bcefghi]	313	343	91	6	77	14	3	1.067	3	13	0	0	1.6	1.6	3.0	slight skinning
	Modoc[degi]	298	391	61	31	63	2	4	1.059	0	8	0	0	0.3	3.5	2.5	
	MSX569-1R[bc]	295	350	85	10	83	2	6	1.056	0	5	0	0	1.3	1.0	1.5	
	6049[a]	275	328	84	16	84	0	0	1.053	0	0	0	0	0.5	3.5	4.5	
	Lollipop[bcdefghi]	97	232	43	55	43	0	2	1.071	0	0	3	0	1.0	2.4	2.3	alligator hide, poor tuber appearance
	MEAN	**354**	**435**	**78**	**18**	**74**	**4**	**3**	**1.063**	**1**	**9**	**1**	**0**	**0.9**	**3.2**	**2.9**	

ROUND WHITE TYPE	MSY111-1[cefi]	543	593	90	5	73	17	5	1.071	0	8	0	0	0.7	3.8	4.3	netted skin, large round tuber type
	Reba[bdefi]	**474**	**505**	**93**	**3**	**78**	**15**	**4**	**1.072**	**0**	**0**	**0**	**2**	**0.8**	**3.1**	**3.3**	**bright skin appearance**
	MSU383-A[e]	421	442	95	4	71	24	1	1.061	0	0	0	0	0.5	2.5	2.5	slight alligator hide
	AF4138-8[bcei]	411	522	78	20	77	1	2	1.063	0	13	0	5	0.8	3.1	2.8	
	MSV179-1[bcei]	392	409	95	2	72	23	2	1.066	0	3	0	0	0.6	2.4	3.7	large round tuber type
	NY157[cefi]	343	400	85	13	80	5	2	1.081	3	13	5	0	0.8	3.1	3.4	
	MSU161-1[be]	310	360	86	11	86	0	3	1.070	0	10	0	0	1.5	2.5	4.5	
	Onaway[c]	**287**	**360**	**80**	**12**	**77**	**3**	**8**	**1.064**	**0**	**10**	**0**	**0**	**1.5**	**3.5**	**2.0**	**deep apical eyes**
	MSX497-6[bcei]	252	274	92	5	86	6	3	1.065	0	3	0	0	0.9	2.4	3.0	bright skin appearance, uniform round tuber type
	MEAN	**381**	**430**	**89**	**8**	**78**	**11**	**3**	**1.068**	**0**	**6**	**1**	**1**	**0.9**	**2.9**	**3.3**	
NOVELTY TYPE	NY161[begh]	446	563	76	21	74	2	3	1.074	4	7	2	0	0.9	3.3	3.5	eyes splashed purple
	AF5414-1RR[be]	387	492	79	13	78	1	9	1.077	0	0	0	0	1.0	2.3	3.0	some purple flesh
	CO8155-2RUS/Y[bcehi]	321	461	68	24	68	0	8	1.075	0	2	0	0	0.6	3.7	2.8	cream colored flesh
	AF5245-1P[bdehi]	308	400	72	25	64	8	3	1.073	4	26	0	0	0.6	3.8	2.6	
	MSX324-1P[bcefi]	303	385	79	17	71	8	5	1.079	0	0	0	2	0.4	3.3	2.3	
	Amarosa[ab]	68	322	13	84	13	0	3	1.067	1	0	0	0	1.5	0.5	2.0	some pink flesh
	MSZ109-5RR[a]	0	124	0	100	0	0	0	1.056	1	0	0	0	0.0	0.0	1.0	very small tuber size, sticky stolons
	MEAN	**262**	**392**	**55**	**40**	**52**	**3**	**4**	**1.071**	**1**	**5**	**0**	**0**	**0.7**	**2.4**	**2.5**	
	TRIAL MEAN	**331**	**443**	**71**	**24**	**67**	**4**	**3**	**1.067**	**1**	**10**	**1**	**1**	**0.9**	**3.3**	**3.0**	

2017 Tablestock Variety Trial Sites
[a]4-L Farms, Allegan County
[b]Crawford Farms, Montcalm County
[c]Horkey Brothers, Monroe County
[d]Jenkins Farms, Kalkaska County
[e]Kitchen Farms, Antrim County
[f]TJJ Farms, Delta County
[g]Walther Farms, Tuscola County
[h]Walther Farms, St. Joseph County
[i]Wilk Farms, Presque Isle County

[1]SIZE
Non-russet tablestock
Bs: 1 1/2" - 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts

[2]SPECIFIC GRAVITY
Data not replicated

[3]RAW TUBER QUALITY
(percent of tubers out of 10)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[4]COMMON SCAB RATING
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

[5]VINE VIGOR RATING
Date: variable
Rating 1-5
1: Slow emergence
5: Early emergence

[6]VINE MATURITY RATING
Date: variable
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

On-Farm Soil Health Research: With Special Reference to Bio-Based Systems

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Project Cooperators: Alan and Brian Sackett, Sackett Potatoes; Mart Otto and Casey Chase, Agri-Business Consultants; R.J. Rant, Soil Health Consulting, Nitri-Link Biosystems; Brad Morgan, Morgan Compost.

Improving soil quality and health in potato production is a key element of the Michigan Potato Industry Commission (MPIC) research agenda. *On-Farm Soil Health Research: With Special Reference to Bio-Based Systems* was initiated in 2014 to develop, validate and demonstrate a bio-based commercial-scale *Challenger* potato production system designed to enhance and maintain soil health in an economically profitable and environmentally sound manner, compared with a conventional *Defender* potato/seed corn production system. This report is designed to present some of the 2017 data associated with the impacts of the 2013-2017 *Defender* and *Challenger* potato yield, tuber quality and soil health indicators: including microbial, remote sensing and econometric analyses.

In 2012, MPIC published a White Paper recommending soil health as a major research, development and education imperative. The Commission sponsored a 96 site Michigan potato soil health survey. The results confirmed the concerns presented in the White Paper, indicating a distinct need for improvement of the soil health associated with Michigan agriculture. In 2013, this five-year (2013-2017) on-farm, field-scale bio-based potato production trial was initiated at Sackett Potatoes in Mecosta County.

The research site design consists of two fields, the *Defender* (SP-26N), a conventional two-year potato-seed corn rotation system and a 54 acre *Challenger* (SP-42), a two-year potato bio-based system including cover crops, manure and compost. SP-26N (north) and SP-42 were selected because of similar cropping histories and soil characteristics. A soil health monitoring system of 32 geo-position points sites (12 in SP26N and 20 in SP42) was established in 2014 (Fig. 1a-b). SP42 was further divided into two *Challenger* systems, designated as SP42E (east) and SP42W (west). In 2015, water stable aggregates were similar in SP-26N and SP-42. 2015 enzymes associated with cellulose, chitin, protein decomposition and P mineralization were higher in SP-42 than in SP-26N. 2015 soil respiration was higher in SP-26N at the beginning of the growing season, compared to SP-42. The reverse was true at the end of the 2015 growing season. At the end of the 2016 growing season, the mean Cornell University soil health indicator score for the *Challenger* was 73; whereas, the mean indicator score for the *Defender* was only 43. The soil health indicator scores included: soil organic matter, ACE (autoclaved citrate extractable protein) soil protein index, soil respiration and active carbon. Both fields were planted to potato in 2017. It was decided at a meeting at Sackett Potatoes on November 23, 2016, that 2017 will be the final year for the project as currently designed. It was also recommended that the project be redesigned for 2018 and beyond based on: 1) A two-year cash crop system integrated with the appropriate soil health building technologies essential for a bio-based system of potato production and 2) A true transdisciplinary formal Michigan potato industry soil health initiative with the dynamic leadership necessary for long-term soil health remediation.

Figure 1. GPS sampling points for SP42 (A) and SP26N (B).

Methodology

Sackett Potatoes (Mecosta County, Michigan) Field SP-42, the *Challenger* and Field SP-26N, the *Defender* were planted to potato and managed throughout the growing season using 2017 Sackett Potato commercial production practices. Multi-spectral remote sensing was done using Air-Scout flyovers for nine dates during the growing season: with special reference to the 32 permanent geo-positioning reference points and vegetative indices/thermal-stability. Nematode community structure was assessed at mid-season. Hand-dug tuber yields and quality assessments were determined for each of the 32 GPS points. Soil samples from each of the 32 sites were collected and partitioned for soil microbial analysis at Michigan State University and twelve soil health indicators at the Cornell University Soil Health Laboratory. Preliminary econometrics were conducted using the 2017 tuber yield data. associated with the 2015 and 2017 potato crops in SP-42 are being be compared to the 2014-2017 cash crop revenues from SP-26N. The 2018 microbial analyses for each of the 32 GPS sites is still being processed. The 2016 data are included in this report. The current plan is to have a detailed final report completed by May 1, 2018.

Results

The results section is divided into summaries of tuber yield, Cornell soil health indicators, vegetative indices/thermal-stability, nematode community structure, microbial analyses and econometrics.

Tuber Yield.- Mean marketable tuber yields ranged from 300 to 462 cwt/acre, with the highest yield associated with the SP42E-4 cover crop challenger (Table 1.)

Table 1. 2017 Potato tuber yields associated with the *Defender* and two *Challenger* systems.

Tuber Yields	SP26N-0[1] (*Defender*)	SP42W-7 (*Challenger*)	SP42E-4 (*Challenger*)
Marketable (cwt/acre) P = <0.001	422	300	462
A's (lbs/10 row feet)	25.15	19.15	32.35
J's (lbs/10 row feet)	2.25	0.30	0.90
B's (lbs/10 row feet)	5.75	7.50	5.30
Total (cwt/acre)	510	415	594

[1]2015 cover crop: SP26N-0, annual rye and 2014 soil fumigation (metam, 40 gpa).
SP42E-4, black oats (62 lbs/A), pearl millett (10 lbs/A), oil seed radish (6 lbs/A), cow pea (22 lbs/A) for a cost of $113.50/A.
SP42W-7, black oats (49lbs/A), pearl millett (5 lbs.A), oil seed radish, (5 lbs/A), cow pea (20 lbs/A), buckwheat (8 lbs/A), sun hemp (6 lbs/A), and annual rye (10 lbs/A) for a cost of $126/A,

Soil Health Indicators (Cornell University System**).**

2017 data for soil aggregate stability, ACE soil protein, active carbon and the entire Cornell University suite of 12 soil health indicators are recorded in Table 2. The *Defender* had the lowest soil health indicator scores for all four the soil health categories individually reported in this document. SP42E-4 had the highest soil health indicator scores for **all** four the indicators. Aggregate stability was **>25% more** in SP42, compared to SP26-0. As anticipated, there was a positive relationship between soil organic matter and active carbon, with distinct clustering based on the site/treatment (Fig. 2). Distinct patterns for the relationship between marketable yield-active carbon and soil organic matter and aggregate stability were observed among the Challengers and Defender including two interesting outliers (Figs. 3-4)

Table 2. 2017 Soil health indicators associated with the *Defender* and & *Challenger* systems.

Soil Health Indicators	SP26-0 (Defender)	SP42W-7 (Challenger)	SP42E-4 (Challenger)
Aggregate Stability (%)	39.8	66.0	69.4
ACE Soil Protein (index value)	3.44	4.54	4.93
Active Carbon (ppm)	203.8	213	313.7
Soil Organic Matter (%)	0.89	1.22	1.37
Cornell Soil Health Score (0-100)*	60.6	61.3	65.3

*A score of 80 is believed to be needed for a healthy soil.

Figure 2. Relationship between active carbon (ppm) and soil organic matter (%).

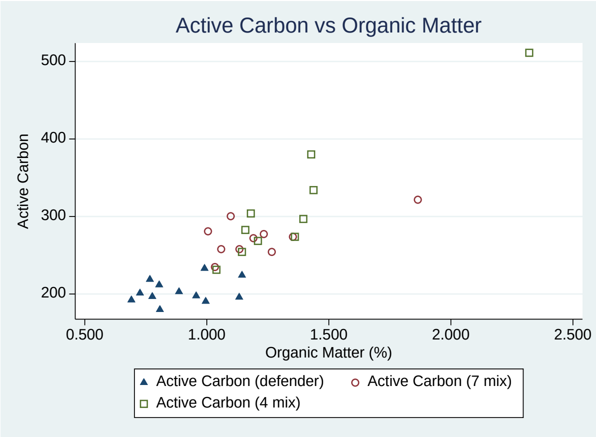


Figure 3. Relationship between active carbon and marketable yield.

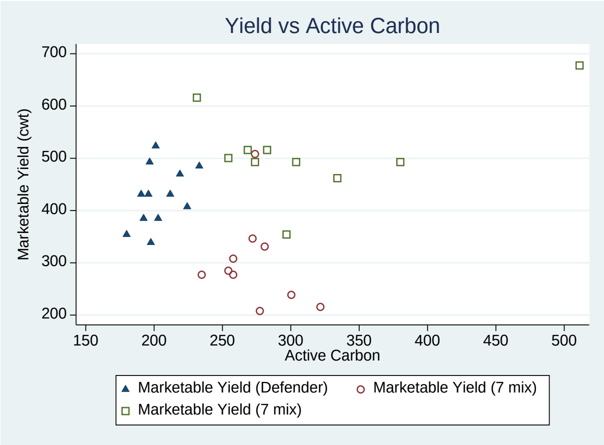
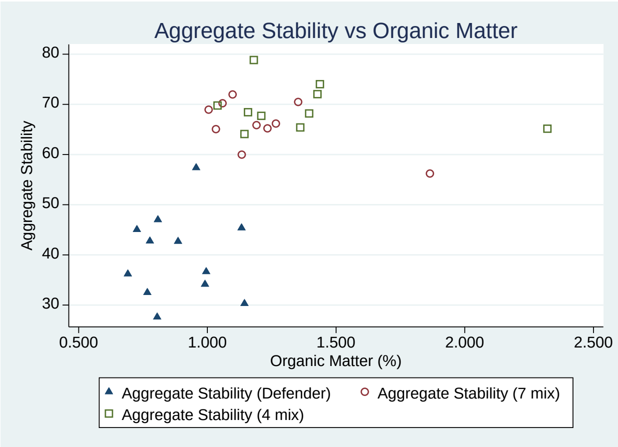


Figure 4. Relationship between soil organic matter and soil aggregate stability.



Vegetative Indices and Thermo Stability.-

The 2016 vegetative index map exhibited distinct differences between SP42W-7 and SP42E-4 that were highly correlated with 2017 tuber yield (Fig. 4). The same was true, for the 2017 thermal stability maps. Used in this manner, thermal stability is a new soil health indicator that appears to have outstanding potential to integrate a large number of parameters over a complete growing season into a single image (Figs 5-6).

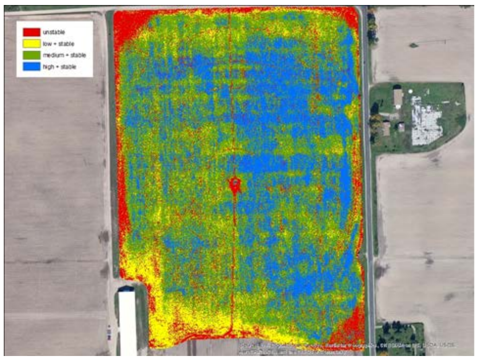


Figure 4. 2016 unmanned aerial vehicle (UAV) enhanced spectral reflectance of SP42 west (left) and SP42 east (right).

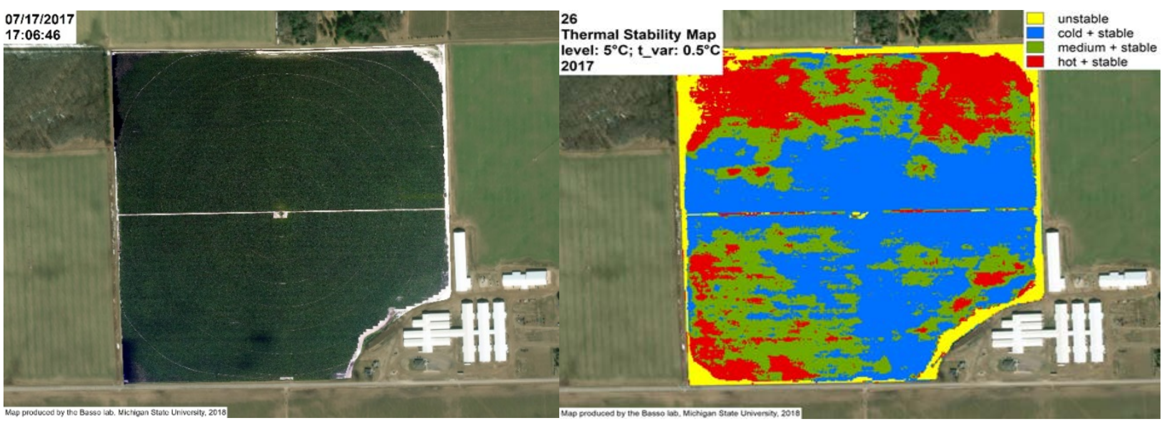


Figure 5. Aerial photograph of SP26 on July 17, 2017 (A) and the associated 2017 Thermal Stability Map (B).

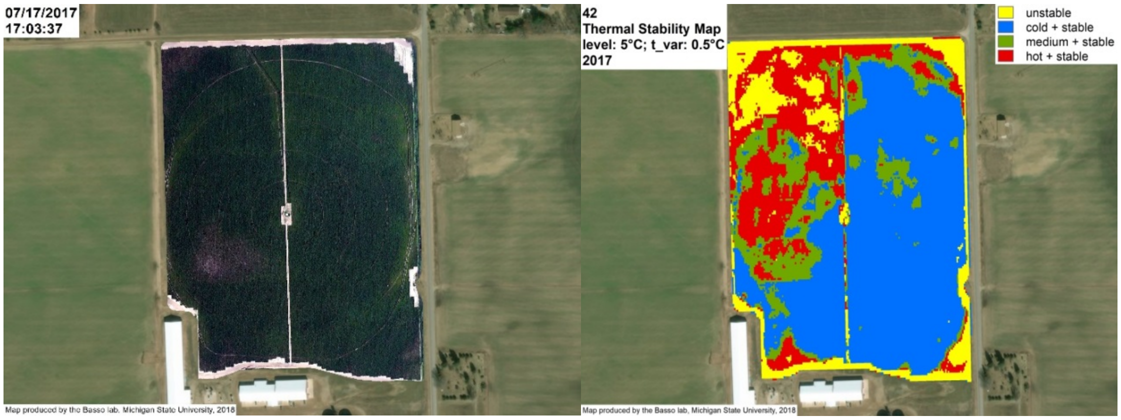


Figure 6. Aerial photograph of SP42 on July 17, 2017 (A) and the associated 2017 Thermal Stability Map for SP42W-7 and SP42E-4 (B).

Nematode Community Structure.- Mid-season population densities of *Pratylenchus penetrans* (Penetrans root-lesion nematode) and bacterivores were highest in the Defender and low in SP42W-7 and SP42E-4 (Table 3). The population density of Dorylaimoidea spp. were highest in SP42W-7, compared to the other two sites. No significant differences were detected in fungivores or carnivores among the three management systems.

Table 3. Mid-season population densities of four nematode groups associated with three potato management systems.

Nematode Group (mid-season)	SP26-0 (Defender)	SP42W-7 (Challenger)	SP42E-4 (Challenger)	Statistic
Pratylenchus penetrans	115	7	13	P = 0.004
Dorylaimoidea spp.	124	2,569	163	P = 0.001
Bacterivores	259	18	18	P = < 0.001
Fungivores	20	7	8	P = 0.260
Carnivores	0.2	0	0.9	P = 0.589

Microbial Analysis.- In 2016, the total number of DNA sequences identified to phyla, class, order, family and genus was 28, 81, 140, 300 and 814 respectively. The results provided baseline information on the bacterial ecology across potato production fields related to soil physical properties, soil disease severity and total yield. Based on numbers of DNA sequences the relative abundance of bacterial taxa was determined for each sample (Figs. 5 and 6). DNA sequence assignment was dominated by 9 of the 21 bacterial phyla recovered, comprising nearly 96% of the total bacterial community assemblage. These phyla were present in every soil sample from the potato production field, and consisted of major known beneficial bacterial groups including Proteobacteria, Acidobacteria, Actinobacteria, Verrucomicrobia, Firmicutes with unclassified bacteria representing >20% of the total bacterial phyla (Fig. 7 A.-B.)

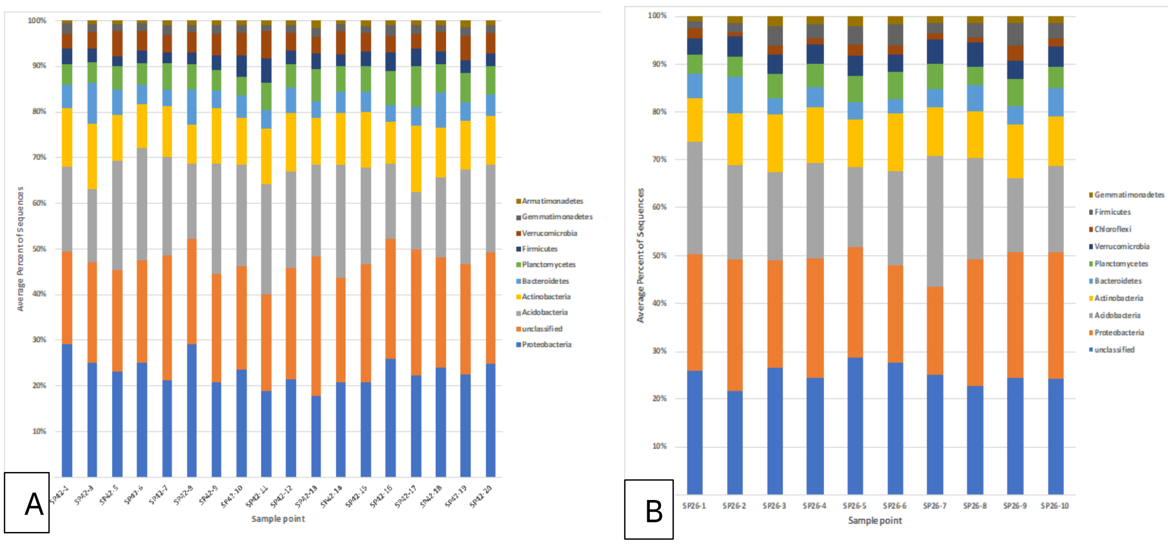


Figure 7. DNA-based bacterial taxa associated with SP42 (A.) and SPW26 (B).

Econometrics.- The yield increase required to generate a net return per acre over a two-year rotation can be approached using the partial budgeting approach. The approach focusing on changes, not one complete enterprise budgets. The challengers system must cover the net added costs and the income foregone from not having a rotation crop. The analysis focuses on the 7-mix treatment since it generated a substantial increase in yields.

The estimate of the 7-Mix treatment yield increase is in the range from an increase of 84 cwt if all sample points are used to 66 cwt when the observation with the outlier organic matter is excluded. Additional statistical methods were also used account for sample properties.

The economic analysis of the two year earnings must consider the net increase in costs including the cost of the seed for the cover crop mix and the cost of application. The elimination in soil fumigation is a cost reduction. Moreover, the loss in net earnings from the rotation crop must be accounted for. Figure xx describes the yield increase required to generate two-year rotation net earnings for $6/cwt and $8/cwt net prices and net income forgone for dropping the rotation crop from $300 to $700 / acre. The net price reflects the gross price less the added harvest, storage, and hauling costs.

The cost/acre used in the analysis were $126 for seed, $6 for application, and $271 for fumigation. Thus, the reduction in cost from fumigation exceeds the added seed and application costs.

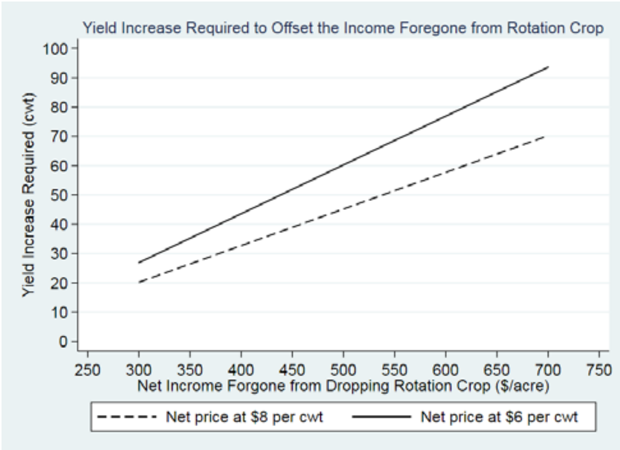


Figure 8. Potato tuber yield increase required to offset income foregone from only having one cash crop in the two-year rotation.

Key Soil Health References

- Basso, B. *et al*., 2011. *Procedures for Initializing Soil Organic Carbon Pools in the DSSAT-Century Model for Agricultural Systems.* J. Soil Sci. Soc. Amer. 75:69-78
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- Magdoff, F. and van Es, H. 2010 *Building Soils for Better Crops (3rd ed).*
- Snapp, S., Bird, G. *et al*., 2016. *Managing Soil Health for Root and Tuber Crops.* MSU EXT Bull. E-3343

Improving Productivity and Sustainability in Potato Production Systems by Increasing Cropping System Diversity

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Abstract:

Due to commercial production practices, soils in potato systems in Michigan experience a significant level of degradation. Mineral withdrawal, poor soil structure and soil microbial community disruption caused by intensive management practices are considered the primary drivers of soil degradation. Disruption of microbial communities affects both physical and chemical soil properties as they contribute to aggregate formation and control soil organic matter (SOM) accrual, decomposition, and nitrogen (N) mineralization. We are proposing an additive process for current potato production systems that increases cropping system diversity and rebuilds microbial community diversity and function. We propose that increasing diversity in the cropping system will lead to greater soil microbial activity, improve nutrient cycling and pathogen suppression, increase soil physical structure, and ultimately, improve soil productivity and crop yields. We will begin by identifying grass species that can add large amounts of biomass to potato production systems, and act as non-hosts to *Verticillium dahliae* and *Pratylenchus penetrans*, the two interacting organisms that cause potato early die syndrome. The optimal grass species will then be added to a legume monoculture commonly used in potato production systems. Results of our research will establish the value of added diversity in a cropping system and provide the potato industry with management recommendations on the efficacy of pearl millet varieties and grasses to improve cropping system productivity. We will document the additive effects of biodiversity in potato cropping systems by measuring changes in microbial community populations and activity. We will quantify these factors by evaluating overall potato yield and tuber quality. The potato industry in Michigan will then have methods to increase cropping system diversity in potato production systems. Potato growers are seeking to optimize cultural practices and biomass production for these new additive cover crop species. A pearl millet optimization trial will occur at Cousineau's Potato Farm in Hardwood, MI. This demonstration trial seeks to optimize mowing timing, seeding mix diversity and rate as well as variety selection to maximize both above and below ground biomass accumulation.

Background:

Due to commercial production practices, soils in Michigan potato cropping systems experience a significant level of degradation. Mineral withdrawal, poor soil structure and soil microbial community disruption caused by intensive management practices are considered the primary drivers of soil degradation. Disruption of microbial communities affects both soil physical and chemical properties because they contribute to aggregate formation and control soil organic matter (SOM) accrual, decomposition, and nitrogen (N) mineralization (Tiemann and Grandy, 2015; Plaza et al., 2013). Under intensive fumigation and tillage practices, soil microbes no longer function at optimal levels to maintain or improve soil structure, SOM and N cycling (Mbuthia et al., 2015; Klose et al., 2006; Toyota et al., 1999). A diverse microbial community also facilitates competition, which maintains a balanced and healthy soil ecosystem. When soil-borne plant pathogens are unchecked by other soil organisms, production systems become out-of-balance, which leads to pathogen pervasiveness and crop failure (Garbava et al., 2004; van Elsas et al., 2002). We propose that increasing diversity in the cropping system will lead to greater soil microbial activity, improve nutrient cycling and pathogen suppression, increase soil physical structure, and ultimately, improve soil productivity and crop yields (Tiemann et al., 2015; van Elsas et al., 2002). We will start by identifying grass species that can add relatively large amounts of biomass to potato production systems, and act as non-hosts to *Verticillium dahliae* and *Pratylenchus penetrans*, the two interacting organisms that cause potato early die syndrome (Phase 1). The optimal grass species will then be added to a legume monoculture commonly used in potato production systems (Phase 2). The addition of one grass species into a potato production system is a relatively small increase in cropping system diversity, but even this small change can help maintain or increase soil health (Tiemann et al., 2015; McDaniel et al., 2014) and increase the productivity of potato cropping systems.

Potato systems that include alfalfa as part of the rotation may see the greatest benefits of increasing cropping system diversity through the addition of a grass species. Several studies have shown that the combination of a grass and legume can have positive effects on microbial community diversity, activity, N mineralization and subsequent crop yields beyond those observed with grass or legume alone (Garbeva et al., 2004; Sainju et al., 2005; Altieri et al., 1999; Wagger et al., 1998). For example, compared to either crop as a monoculture, hairy vetch combined with rye produced greater cover crop biomass and greater subsequent crop biomass and grain yields (Sainju et al. 2005). Additionally, these same cover crop mixtures compared to monocultures had different effects on microbial biomass (Sainju et al., 2006). In a controlled laboratory soil incubation, decomposition of legume-grass mixtures resulted in increased microbial biomass and more even release of N (McDaniel et al., 2014; McDaniel et al., in revision). We hypothesize that the mixture of legume and grass species in a potato system rotation could provide some of these same benefits.

Potato cropping systems in Michigan's Upper Peninsula offers an ideal location to explore different culture practices in cover crop species (Phase 3). We will investigate the effects of mowing timing, variety, variety combinations and seeding rate on biomass accumulation. Pearl millet (*Pennisetum glaucu*) and associated cultivars are warm season grasses that can produce large amounts of biomass. Foxtail or German millet (*Setaria italic*) and Japanese millet (*Echinochloa esculenta*) are other grass species with grower interest for biomass production in the Upper Peninsula. Additionally, the effect of mowing timing can delay bolting, prolong heading and delay maturation, thus increasing biomass production.

Phase 1: Identification of Optimal Grass Species

<u>Objective 1</u>: Identify pearl millet varieties and other grass species that produce the greatest amount of above and below ground biomass.

<u>Objective 2</u>: Identify which grass species are the poorest hosts to *V. dahliae* and *P. penetrans*.

In the spring of 2015 and 2016, grass species comparison trials occurred at the Montcalm Research Center (MRC), Montcalm County, MI comparing performance of the grass varieties. We chose the grass species used in the 2015 trial based on previous research and anecdotal evidence that these species enhance disease and pest suppression in potato systems. The varieties were evaluated for production of above and below ground biomass, maturity (as a function of bolting), and likelihood of being a non-host or nematode-antagonistic with respect to *P. penetrans* root lesion nematode. In 2015, the following species were evaluated: common oat, (*Avena sativa*, 'IDA'); pearl millet, (*Pennisetum glaucum,* 'Tifleaf 3', 'Millex 32', 'CFPM 101'); proso millet, (*Panicum miliaceum*, 'White'); German millet, (*Setaria italica)*; foxtail millet, (*Setaria italica*, 'White Wonder') and; Japanese millet, (*Echinochloa esculenta*). It was determined that the pearl millet varieties produced the highest amounts of biomass, while the Japanese millet varieties produced the lowest amount (Table 1). Although not statistically significant, the pearl millet varieties tended to have fewer nematodes present in the soil and on the root tissue than the other grass species tested (Table 1).

In 2016, this land was planted with the potato variety 'Superior.' Based on previous grass crop history in 2015, potato yield, tuber quality and presence of *V. dahliae* and *P. penetrans* were evaluated. Potato production in the pearl millet treatments, specifically Tifleaf and MIllex 32, although not significantly significant, produced higher total yields (Table 2). Root lesion nematode numbers were not significantly different between treatments, but pearl millet CFMP 101 had the lowest *Verticillium* concentration.

In the spring of 2016, the three pearl millet varieties and four other grass species [corn, (*Zea mays spp*.), sorghum sudangrass (*Sorghum bicolor x Sorghum bicolor* var. Sudanese), teff (*Eragrostis tef*) and one other pearl millet variety (*P. glaucum* 'Wonderleaf')] underwent side-by-side screening at MRC to compare above and below ground biomass production and their effects on *V. dahlia* and *P. penetrans* abundance. The 2016 total biomass accumulation results are listed in Table 3. The corn control treatment produced the highest total biomass, but the grains were included in weight calculation, artificially inflating it. There was no significant difference in total biomass produced between the remaining grass species. *Sorghum bicolor x S. bicolor* var. Sudanese and teff 'Dessie' produced the least amount of biomass.

In 2017, we proposed repeating parts 1 and 2 of phase one of this proposal. Due to a trial planting error, part one of the study was not planted and will be delayed until the Spring of 2018. No cover crop biomass data was collected in 2017. Part two is replanting the 2016 cover crop study to the potato variety the following season (2019). Cover crop treatment effects on potato yield and quality performance in 2017 are presented in Table 4.

Table 1: 2015 Total Shoot Biomass and Mean Root Lesion Nematode Counts

Cover Crop Treatment Information				Agronomic Data		
Species	**Common Name**	**Variety**	**Source**	**Total Shoot Biomass**	**RLN Soil**	**RLN Roots**
Avena sativa	Common Oat	Ida	Michigan Crop Improvement	3880^{bc}	0.7	9.0
Pennisteum glaucum	Pearl Millet	Tifleaf 3	Gayland Ward Seeds	6743^{ab}	1.3	4.7
Pennisteum glaucum	Pearl Millet	Millex 32	Sorghum Partners	8582^{a}	1.0	0.7
Pennisteum glaucum	Pearl Millet	CFPM 101	AERC, Inc.	8614^{a}	1.3	5.3
Panicum miliaceum	Proso Millet	White	Green Cover Seed	2105^{cd}	2.3	11.3
Setaria italica	German Millet	N/A	Green Cover Seed	3992^{bc}	0.3	0.0
Setaria italica	Foxtail Millet	White Wonder	Green Cover Seed	3769^{bc}	2.3	4.3
Echinochloa esculenta	Japanese Millet	N/A	Green Cover Seed	709^{d}	1.3	10.7
Echinochloa esculenta	Japanese Millet	N/A	Athens Seed Co.	714^{d}	1.3	8.7
			ANOVA:	<.0001	NS	NS

Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05). NS indicates no significant differences
RLN= root lesion nematodes, extracted from 100g of soil and 1g of plant root tissue. Testing performed by MSU Diagnositic Services

Table 2: 2016 'Superior' Potato Tuber Yield, Quality, and Disease Evaluation

2016 MRC Millet Trial Potato Quality and Yield Data
Montcalm Research Center, Entrican, MI

	CWT/A		PERCENT OF TOTAL[1]					RAW TUBER QUALITY[2] (%)				COMMON SCAB	ROOT LESION NEMATODE		VERTICILLIUM DAHLIAE
Cover Crop Treatment	US#1	TOTAL	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	RATING[3]	(#/100 g soil)	(#/1 g root tissue)	(# of stems positive out of 10
Pearl Millet (Tifleaf 3)	252^{a}	306^{a}	16.7	81.3	0.3	1.7	1.071	0	19	2	11	2.7	2.7	5.3	3.6^{bc}
Pearl Millet (Millex 32)	247^{ab}	298^{a}	15.6	81.7	0.8	1.8	1.076	0	18	1	11	2.6	3.0	6.3	4.6^{ab}
Pearl Millet (CFPM 101)	235^{ab}	282^{ab}	15.6	83.2	0.0	1.1	1.072	1	17	2	9	2.7	1.7	16.6	1.3^{c}
German Millet	231^{abc}	286^{ab}	17.6	80.7	0.0	1.7	1.071	2	28	2	10	2.7	2.0	9.0	7.0^{a}
Japanese Millet	202^{abc}	250^{abc}	19.6	78.8	0.2	1.4	1.069	3	25	3	11	2.5	4.0	14.3	2.3^{bc}
Foxtail Millet	185^{bc}	235^{bc}	24.0	77.7	0.2	0.9	1.070	1	22	3	4	2.5	4.0	11.6	2.3^{bc}
Oats	166^{c}	219^{c}	17.6	74.0	0.2	1.8	1.070	2	17	4	8	2.5	0.0	5.0	3.0^{bc}
MEAN	**217**	**268**	**18**	**80**	**0**	**1**	**1.071**	**1**	**21**	**2**	**9**	**2.6**	**2.5**	**9.7**	**3.4**
ANOVA	0.0006	<0.0001	0.41	0.39	0.19	0.82	0.27	0.52	0.16	0.67	0.50	0.91	0.52	0.74	**0.04**
HSD	59.8	5.80													

[1]SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
PO: Pickouts

[2]TUBER QUALITY
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3]COMMON SCAB RATING
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though co
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05)

Table 3: 2016 Grass Cover Crop Total Biomass (lb/A) and Height (In)

Species	Common Name	Variety	Total Biomass (lb/A)	Maximum Height (In)
Zea mays	Corn	-	41077^{a}	93
Pennisteum glaucum	Pearl Millet	CFMP 101	13879^{b}	103
Pennisteum glaucum	Pearl Millet	Millex 32	13289^{b}	96
Pennisteum glaucum	Pearl Millet	Tifleaf 3	11022^{b}	54
Pennisteum glaucum	Pearl Millet	Wonderleaf	13847^{b}	92
Eragrosis tef	Teff	Dessie	9028^{b}	76
Sorghum bicolor x S. bicol var. sudanese	Sorghum sudangrass	Sweet Bites	10274^{b}	40

Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05)

Corn aboveground biomass includes grain weight

Maximum height was measured on 9/12/17

Table 4: 2017 'Superior' Potato Tuber Yield, Quality, and Disease Evaluation

2017 MRC Millet Trial Potato Quality and Yield Data
Montcalm Research Center, Entrican, MI

Cover Crop Treatment	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] Bs	PERCENT OF TOTAL[1] As	PERCENT OF TOTAL[1] OV	PERCENT OF TOTAL[1] PO	SP GR	RAW TUBER QUALITY[2] (%) HH	RAW TUBER QUALITY[2] (%) VD	RAW TUBER QUALITY[2] (%) IBS	RAW TUBER QUALITY[2] (%) BC	COMMON SCAB RATING[3]	[5]VERTICILLIUM DAHLIAE cycle threshold
Pearl Millet (CFPM 101)	281^{a}	350^{a}	13.2	80.1	0.0	6.7	1.075	0	2	0	2	1.9	32.1^{a}
Pearl Millet (Wonder Le:	266^{ab}	347^{a}	15.7	76.4	0.0	7.9	1.075	0	3	0	2	1.9	32.4^{a}
Pearl Millet (Millex 32)	255^{abc}	335^{ab}	16.4	76.1	0.0	7.5	1.077	0	3	0	2	1.8	30.4^{b}
Teff	229^{bcd}	310^{abc}	19.3	73.8	0.0	6.8	1.074	0	3	0	2	1.8	32.1^{a}
Sorghum Sudangrass	224^{bcd}	293^{bc}	17.7	76.2	0.0	6.1	1.073	0	4	0	1	1.8	31.8^{ab}
Pearl Millet (TIFLEAF 3)	209^{cd}	285^{c}	22.5	70.6	0.1	6.8	1.073	0	3	0	2	1.7	30.6^{b}
Corn	205^{d}	287^{c}	23.2	71.1	0.1	5.5	1.074	0	3	0	2	1.9	31.5^{ab}
MEAN	**238**	**315**	**18**	**75**	**0**	**7**	**1.074**	**0**	**3**	**0**	**2**	**1.8**	**31.6**
[4]ANOVA	**<.0001**	**<.0001**	**<.0001**	**0.001**	0.55	0.68	**0.004**	0.06	0.25	0.18	0.27	0.59	**0.04**
HSD	**46.92**	**46.01**	**6.34**	**6.96**									

[1]SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
PO: Pickouts

[2]TUBER QUALITY
(percentage of tubers out of 10)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3]COMMON SCAB RATING
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

[4]ANOVA
Analysis was performed on non-aggregated data where each cover crop treatment had 16 replicates that are averaged here.
Connecting letters reports were determined using Tukey-Kramer HSD with $p<0.05$
HSD= Honest Significant Diference.

[5]Cycle threshold describes the amount of time to amplify DNA. Higher cycle thresholds correspond to lower amounts of viral DNA
Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05)

Phase 2: Incorporation of a Grass into a Potato Production System

<u>Objective 1</u>: Determine how an increase in cropping system diversity affects SOM decomposition, N mineralization, soil microbial community diversity, and soil aggregation.

<u>Objective 2</u>: Determine which grass species confers the greatest benefits when used to increase cropping system diversity.

In the spring of 2016 two separate cover crop plots were planted at Kitchen Farms, Elmira, MI. One plot was planted into a bare soil field, previously potatoes in 2015. The second plot was planted into a one-year-old alfalfa crop (two years out of potatoes). This plot was planted just after the first cutting of alfalfa. Both seedings used the same eight treatments. The first treatment was alfalfa alone followed by the three pearl millet varieties from the 2015 grass species trial, sorghum-sudan grass, teff, cereal rye, and annual rye grass. The grasses were co-seeded with alfalfa in the year one planting and were drilled into the standing alfalfa in the second year planting. All treatments were no-till drilled in a randomized complete block design with four replications. In these grass plus alfalfa plots, we measured above and below ground biomass production, soil respiration, potentially mineralizable C and N, and extra-cellular enzyme activities.

From the co-seeded plot data (Table 5) the warm season grasses with the exception of teff and annual ryegrass produced the most total biomass and reduced alfalfa biomass accumulation compared to the alfalfa alone treatment. Pearl millet 'CFPM 101' had the highest above ground biomass. All treatment seeding rates will be adjusted as we proceed to balance the biomass production of both species. The interseeded plot data (Table 5) shows that pearl millet Tifleaf 3 outperformed all other treatments except Millex 32 in biomass production. This demonstrates that cultivar specificity is important in relative competition with alfalfa. None of the interseeded grass species significantly reduced alfalfa production.

In 2017, planting rates were adjusted and the number of grass species and cultivars tested were reduced to the most promising. Mowing times were inconsistent among years. The 2017 treatments were planted June 14th and included pearl millet (Canadian forage pearl millet 10, Millex 32, Tifleaf 3) and sorghum sudangrass (Super sugar), plus a control treatment with only alfalfa. In 2017, the alfalfa alone treatment in the co-seeded plot produced a significantly higher amount of biomass. In the interseeded plots, there was not significant differences, but Millex 32 and Super sugar produced the largest amount of total biomass in conjunction with alfalfa (Table 6).

Table 5: 2016 Crop Biomass (lb/A) at Kitchen Farms

		Co-Seeded Plots			Interseeded Plots	
Species	**Variety**	**Grass total dry biomass**	**Alfalfa Total Dry Biomass**	**Weed Total Dry Biomass**	**Grass total dry biomass**	**Alfalfa Total Dry Biomass**
Alfalfa only	-	-	1399^{a}	4627^{a}	-	4911
Pearl Millet	CFPM 101	9880^{a}	485^{bc}	606^{c}	292^{bc}	4639
Pearl Millet	Millex 32	9600^{a}	610^{bc}	814^{bc}	530^{ab}	4885
Pearl Millet	Tifleaf 3	8797^{ab}	308^{c}	623^{c}	776^{a}	4093
Sorghum sudangrass	Super sugar	10009^{a}	434^{c}	572^{c}	303^{bc}	4766
Teff	Dessie	4736^{bc}	363^{c}	1327^{bc}	16^{c}	5547
Cereal Rye	Guardian	2882^{b}	1195^{a}	2193^{b}	248^{bc}	5148
Annual Ryegrass	Centurion	4571^{bc}	995^{ab}	1249^{bc}	126^{c}	4408

Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05)

Table 6: 2017 Crop Biomass (lb/A) at Kitchen Farms

		Co-Seeded Plots			Interseeded Plots	
Species	**Variety**	**Grass total dry biomass**	**Alfalfa Total Dry Biomass**	**Weed Total Dry Biomass**	**Grass total dry biomass**	**Alfalfa Total Dry Biomass**
Alfalfa only	-	-	8313^{a}	4627^{a}	-	4677
Pearl Millet	CFPM 101	4602	4060^{b}	606^{c}	675	3844
Pearl Millet	Millex 32	4539	3666^{b}	814^{bc}	441	5249
Pearl Millet	Tifleaf 3	3507	4448^{b}	623^{c}	888	4005
Sorghum sudangrass	Super sugar	6586	2797^{b}	572^{c}	786	4677
		NS	<.0001		NS	NS

Treatments followed by different superscript letters have a stastically significant differences using Tukey's HSD test (a=.05). NS indicates no significant differences

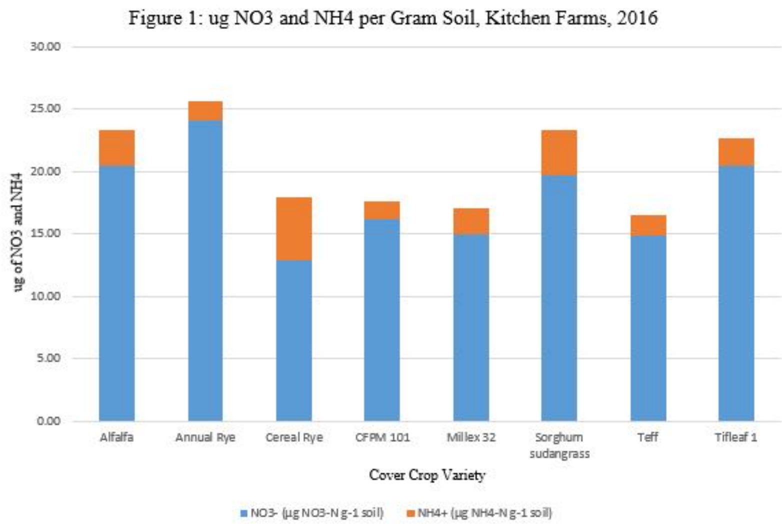

Table 7: Planting Rate, Mowing Treatment, and Total Biomass of CFPM 101 in 2017

Planting rate (lbs/A)	Mowing	Total biomass (lbs/A)
15	no	5057
15	no	3698
15	no	1505
15	yes	8676
15	yes	3303
15	yes	1238
22	no	5271
22	no	3986
22	no	3930
22	yes	5873
22	yes	4233
22	yes	1580

Phase 3: Determine Best Management Practices for Pearl Millet Growth in the Upper Peninsula

Objective 1: Determine best management practices for optimizing pearl millet growth in the Upper Peninsula.

For the past two seasons a grass cover crop demonstration trial has been planted at the Cousineau's seed potato farm in Hardwood, MI. In addition, the Cousineau family has been planting various millet species on a larger scale in the year before potatoes. It is unclear how planting time and mowing impacts biomass production at this northern latitude. Based on observations, plants that emerged following a mid-May planting but appeared stunted, whereas planting in late-May or early-June resulted in more vigorous growth during the shorter growing season of these warm-season grasses. Mowing could benefit this system by potentially increasing biomass accumulation and breaking up residues that can impede field operations during the potato season. At the end of the season, total biomass was calculated for each planting rate and mowing treatment. The highest yield occurred in the 22 lbs/A mowed treatment, and the lowest yield occurred in the 15 lbs/A non-mowed treatment (Table 7). No statistical analysis was conducted.

Materials and Methods:

Phase 1

The first part of this phase of the project is the pearl millet screening study. Seven grass species were planted in a four replication, randomized block design at the MRC in early June 2017. Each plot is 20 by 45 feet. Each grass species was seeded at a depth of one inch and at a rate of fifteen lbs/A. Each grass plot was evaluated for above ground biomass production using one 0.25 m^2 quadrat prior to each mowing during the growing season and prior to the killing frost. Below ground biomass was evaluated once just prior to a killing frost.

In 2017, the potato variety 'Superior' was planted over the 2016 grass species trial at MRC. Sixteen, 34 inch rows were planted perpendicular to the grass trial plots. The in-row seed spacing for the 'Superiors' was 10 inches. Four, 15 foot plots were harvested from the potatoes in each of the grass plots in the fall. Each potato plot was evaluated for US#1 and total yield, internal tuber quality, specific gravity, early die syndrome, vine maturity and the abundance of *V. dahliae* and *P. penetrans* (2016 only).

Phase 2

This experiment was set up as a randomized complete block with eight treatments in 2016 and five treatments in 2017. The 2016 grass species were planted June 17th and included pearl millet (Canadian forage pearl millet 101, Millex 32, Tifleaf 3), sorghum sudangrass (Super sugar), cereal rye (Guardian), teff (Dessie), and annual ryegrass (Centurion), and a no grass control treament. The 2017 treatments were planted June 14th and included pearl millet (Canadian forage pearl millet 10, Millex 32, Tifleaf 3) and sorghum sudangrass (Super sugar), plus a control treatment with no grass. In each year there were two plots, one planted at the same time as alfalfa (co-seeded) and one planted into 2nd year, established alfalfa at the time of first cutting (interseeded). Plots received overhead irrigation per the schedule set by the Kitchens. Weeds within the plots were not controlled during the year grasses were present due to lack of herbicide options. During the alfalfa only years weeds were controlled with glyphosate on Roundup Ready alfalfa.

Prior to each mowing, aboveground biomass (cut at mowing height) was measured for both the alfalfa and the grass species. Prior to frost (co-seeded) or termination (interseeded), above- and belowground biomass were recorded. We collected soil samples from the experimental plots after grasses were established.

We assessed microbial activity in two ways: extracellular enzyme activity (EEA) and respiration rates. We measured the enzyme activity to asses the presence and concentration of microbes that make nitrogen, carbon, and phosphorous available in the soil. Soil respiration rate assessment quantified the level of microbial activity, SOM content, and decomposition rate. We will perform microbial community structure analyses and *V. dahliae* colonization on soil and potato plant tissue samples respectively collected in 2018. This analysis will indicate the presence and abundance of *V. dahliae* in each cover crop regime. The DNA Sequence database will be mined from the total bacteria community dataset to identify DNA sequences corresponding to beneficial and plant pathogen antagonistic bacteria. Additionally, we will determine bacterial community diversity and richness.

Phase 3

In 2017, our experiment was designed to study the effect of planting date and mowing frequency on pearl millet biomass production. However, due to the unusually wet and somewhat cool spring, the first two planting dates (May 15 and May 31) resulted in no pearl millet stand. There were 20.37 inches of rain between May and September compared to a 24 year average of 15.78 inches. We then chose to look at the impact of planting rate and mowing frequency on pearl millet biomass production with the final planting date (June 13). The experiment was set up in a split plot design with three replications. The main plot factor was planting rate (treatments of 15 and 22 lbs/A) and the subplot factor was mowing regime (treatments of one mowing and not mown). Based on previous research conducted at the MRC, 'CFPM 101' was used. Cover crop emergence was recorded one month after planting by counting the number of plants in three 0.25 m^2 quadrat in each plot. At the time of mowing (August 22), aboveground biomass (cut at mowing height) was measured. Prior to termination and frost (September 11), total biomass were recorded.

Outcomes:

Results of this research provide the potato industry with information regarding the efficacy of pearl millet varieties and grasses to improve cropping system productivity. This project has established the value of added diversity in a cropping system. Our experiment documented the additive effects of biodiversity in a cropping system by measuring changes in microbial community populations and activity. We quantified these factors by evaluating potato yield and tuber quality. As a result of this work, the potato industry in Michigan will have strategies to increase cropping system diversity in potato production systems and understand best practices for warm season grass production in Michigan.

Phase 1

In 2015, thee pearl millet varieties (Tifleaf 3, Millex 32, and CFPM 101) produced the most biomass using statistical analysis. The potato yields of 'Superior' the following year partially support our hypothesis. There is a statistically significant higher US #1 and total yield of potatoes in 2016 grown in the Tifleaf 3 and Millex 32 plots compared to those grown in the foxtail millet and oats plot. Potatoes grown after CFPM 101 also had a statistically higher total yield than those grown after oats. While the data does not show a "best" cover crop variety for increased potato yield the following year, it does indicate that the pearl millet varieties tend to support higher potato yields. This is further confirmed by the potato yield data in 2017. Potatoes grown after CFPM 101 and pearl millet Wonder Leaf had a significantly higher yield that those grown after sorghum sudangrass and corn. Future study on Tifleaf 2, CFPM 101, and Wonder leaf are recommended to create best practices for planting date, spacing, and mowing time that result in the highest yield increase the following year.

In 2017, we observed a statistically significant lowest incidence of *V. dahliae* in German millet, and the lowest amount of fungal DNA from the species in pearl millet CFPM 101 and Wonder Leaf, and teff. In 2016, there was no significant difference in the incidence of plant or soil root lesion nematode. This data was not available for 2017. Plant available nitrogen at each cover crop treatment site in 2016 was also assessed at Kitchen's Farms. While there was not a statistically significant difference, teff and Millex 32 had the lowest amount of plant available nitrogen while annual rye, Sorghum sudangrass, and alfalfa had the highest amount (Figure 1). This indicates the presence and productivity of soil microbes producing enzymes that break down inaccessible nitrogen in the soil and make it available for plant uptake.

In 2018, we propose planting the same cover crops evaluated in 2017, and then planting 'Superior' potatoes the following year to further evaluate potato yields after different cover crops. We expect to see the three above mentioned pearl millet varieties perform well again in the future, as they appear to support higher potato yields and may be less susceptible to *V. dahliae.*

Phase 2

In 2016, the co-seeded plots were dominated by the grass species with poor alfalfa establishment. Weed populations were also problematic in the poor stands of 2016. Most of the pearl millet varieties and the sorghum sudangrass produced more biomass compared to the other varieties, which were then oitted in 2017. The better establishment of alfalfa in 2017 and the 50% reduction in planting rate reduced grass biomass accumulation by approximately 3,500-4,000 lbs/A compared to 2016. However, the grass to alfalfa biomass ratio was about 50:50. The total biomass produced in these plots (grass and alfalfa) ranged from 8,000 to 9,400 lbs/A.

In 2016, the interseeded plots had very low grass biomass accumulation, ranging from 16 to 776 lbs/A (Table 5). Again, the cereal rye, annual ryegrass, and teff plantings were not competitive in this environment and were omitted in 2017. In 2017, the grass biomass accumulation ranged from 440-890 lbs/A (Table 9), about 10-20% of the alfalfa biomass. Significant gains were not made by increasing the seeding rates by 50% from 2016 to 2017. The data show that co-seeding is preferable to interseeding to obtain a balanced mix of Alfalfa and a grass species. In the future, we plan to plant 'Superior' potatoes over the 2017 co-seeded and interseeded plots and assess yield, disease pressure, and soil microbial composition, and soil mineral composition. We expect that the interseeded pearl millet and Alfalfa plots will support the highest potato yields.

Phase 3

No biomass difference was observed at different planting rates in 2017, so future plantings will be conducted with seedings of 15 lbs/A. The data from 2017 indicate that a later planting date is preferable, so only the latest planting date will be used in 2018. We propose the following experimental design consisting of five grass treatments (including two equal mixtures) and three moving treatments (no mowing, early mowing, and mid-season mowing). We predict that earlier mowing will increase millet biomass production, which in turn will support a higher potato yield.

Table 8: Proposed Experimental Design for Phase 3 CFPM 101 Evaluation

mow 2					
mow 1					
no mow					
mow1					
mow 2					
no mow					
no mow					
mow 1					
mow 2					
no mow					
mow 2					
mow 1					
	Ger	Jap	Perl	GerP	JapP

Mow 1	Early mowing (3 weeks after planting)
Mow2	Mid-mowing (6 weeks after planting)
No mow	Late mowing/termination (Sept 15)
Ger	German Millet
Jap	Japanese Millet
Perl	Pearl Millet
GerP	50/50 German/Pearl Millet
JapP	50/50 Japanese/Pearl Millet

Potato (*Solanum tuberosum)* "Superior"
Potato Early Die, Verticillium Dahliae, Pratylenchus penetrans

N. Rosenzweig, J. Calogero, C. Long, and S. Mambetova
Plant, Soil, and Microbial Sciences
Michigan State University

In-furrow and foliar treatment programs for control of potato early die (PED)-Entrican 2017

A field trial was established 25 May (43°21'9.24"N and longitude - 85°10'34.61"W) at the Montcalm Research Center, Entrican MI to evaluate selected in-furrow and foliar fungicides, fumigants and nematicides for early die control (Table 1). US#1 ‘Superior’ tubers were mechanically cut into approximately 2 oz seedpieces 19 May and allowed to heal before planting. These trials were conducted using potato cultivar ‘Superior’ due to its susceptibility to Verticillium wilt and its commercial use throughout the state of Michigan and the Midwestern US potato growing region. A randomized complete block design with four replications was used for the experiment, with each plot consisting of four 22-ft-long rows spaced 34 in. apart with tubers 10 in. apart in the row. A 3-ft not-planted alley separated the two-row beds. 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). Application times included: Pre-planting/pre-plant incorporated (A); Seed treatment (B); In-furrow at planting (C); 2 in emergence (D); 7 Days after 2 in emergence (E). In-furrow, at-planting applications of fungicide were delivered with a hand-held R&D spray boom delivering 10 gal/A (50 p.s.i.) and using one XR8002VR nozzle per row. A non-treated control was compared with 23 different treatment programs to evaluate their efficacy in controlling potato early die (PED) based on application time (Table 1). 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 cultivation 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 Pro Systemic Pro 7 oz/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.

Soil samples were taken May 2 from each plot prior to applications of treatments. Five samples from each plot row (ten total) were collected with a 25 mm JMC soil corer (Clements Assoc., Newton, IA) to a depth of 100 mm and combined in a one gallon sample bag for total of ~1000 g/ soil per sample. Soil samples were sent to the MSU Plant Diagnostic Clinic to determine populations of *Verticillium dahliae* colony forming units (CFUs) and populations of *Pratylenchus penetrans*, Root-Lesion Nematode (RLN) in each plot. Similarly, soil was sampled on 21 Jul (55 DAP) and sent to the MSU Plant Diagnostic Clinic to determine populations of RLN in each plot. To determine the colonization of *V. dahliae* per ml of plant sap, stem sections approximately 15 cm long were cut from 3 plants per plot, with sterile razor blades, from the soil line approximately 55 DAP and DNA was extracted from the plant samples and subjected to quantitative PCR detection targeting *V. dahliae*. Plant stand was rated 20 (14 Jun), 27 (21 Jun) and 34 (28 Jun) days after planting and relative rate of emergence was calculated as the Relative Area Under the Emergence Progress Curve [RAUEPC from 0–34 DAP, maximum value = 100]. Plots were not inoculated but relied on natural infestation of *Verticillium dahliae* for disease establishment. Severity of PED was measured as a Verticillium Wilt Scale: 0=No Verticillium wilt seen; 1=Small amounts of yellow and flagging of petioles; 2=Moderate amounts of yellowing and flagging of petioles, some of the flagged petioles becoming necrotic; 3=Symptomatic plants start to have stems stand straight up while the rest of the plant is laying down, the upright stems are yellow and petioles are wilted and necrotic; 4=Majority of the plot has upright necrotic stems and 5=Entire plot is necrotic, upright stems are brown and petioles are wilted and necrotic, tuber may have brown speckling throughout the stem-end. Severity of PED was rated 70 (3 Aug), 84 (17 Aug) and 91 (24 Aug) days after planting and the relative rate of disease progression was calculated as the Relative Area Under the Disease Progress Curve [RAUDPC from 0–91 DAP, maximum value = 100].

Plots (1 x 22-ft row) were machine-harvested on 14 Sep (112 DAP) and individual treatments were weighed and graded. Randomly selected samples of 10 tubers per plot were washed and assessed for stem end vascular beading incidence (%).

Meteorological Data

Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Sept. Average daily air temperature (ºF) was 55.0, 68.5, 69.8, 64.9 and 63.5 (May, Jun, Jul, Aug and Sep respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except Sep with 5 days. Average daily relative humidity (%) over the same period was 68.0, 74.6, 74.0, 75.2 and 73.4. Average daily soil temperature at 4 in. depth (ºF) over the same period was 58.1, 69.4, 71.3, 70.2 and 69.8. Average daily soil moisture at 4 in. depth (% of field capacity) over the same period was 12.4, 14.0, 9.4, 6.7 and 7.3. Precipitation (in.) over the same period was 1.98, 6.37, 0.92, 1.36 and 0.7". Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

Results

The 2017 growing season provided environmental extremes of excessive moisture early in the season and moisture stress at other times. However, a prolonged period of unusually dry weather continuing from early Jul to mid-Aug resulted in environmental conditions that were conducive to PED establishment and development. No treatments were significantly different from the non-treated control in percent plant emergence or rate of emergence (RAUEPC). However, there was a significant difference in plant stand among 13 treatments (Table 1). Moreover, there was a significant difference in rate of emergence (RAUEPC) among nine treatments (Table 1). Three treatments including: FLU+CTD 15 oz/A (C); Vydate 310 SL 6.5 oz/A (C, D and E), and PicPlus 98 lb/A (A) had significantly lower PED disease severity (91 DAP) compared to the non-treated control (Table 1). Additionally, among 11 treatments PED disease severity was significantly different (Table 1). The rate of disease progression (RAUDPC) of PED for three treatments was significantly higher than the non-treated control (Table 1). These treatments included: Velum Prime 6.5 oz/A (C), Luna Tranquility 11.2 oz/A (D and E); CruiserMaxx 0.31 oz/CWT (B), Elatus 7.7 oz/A (D), and NIMITZ 1.5 pt/A (C). There were five treatments that had significantly lower total yield (CWT) than the non-treated control (Table 1). These treatments included: Velum Prime 6.5 oz/A (C); Velum Prime 6.5 oz/A (C), Luna Tranquility 11.2 oz/A (D and E); CruiserMaxx 0.31 oz/CWT (B), Elatus 7.7 oz/A (C and D); Majestine 1 gal/A (C and D) and NIMITZ 1.5 pt/A (C). There were eight treatments that had significantly lower US#1 yield (CWT) than the non-treated control (Table 1). These treatments included: TI435 600 SC 4.653 oz/A (C); FLU+CTD 15 oz/A (C); Velum Prime 6.5 oz/A (C); Velum Prime 6.5 oz/A (C), Luna Tranquility 11.2 oz/A (D), Movento HL 2.5 oz/A (E); Velum Prime 6.5 oz/A (C), Luna Tranquility 11.2 oz/A (D and E); CruiserMaxx 0.31 oz/CWT (B), Elatus 7.7 oz/A (C and D); Majestine 1 gal/A (C and D) and NIMITZ 3.5 pt/A (A), ADA 58701 7.6 fl oz/A (C). There were no treatments that were significantly different in B-size yield (CWT) compared to the non-treated control (Table 1). However, there was a significant difference in B-size yield (CWT) among seven treatments (Table 1). The treatment of NIMITZ 1.5 pt/A at planting (C) had significantly higher vascular discoloration compared to the non-treated control (Table 1). There was a significant difference in vascular discoloration among 11 treatments (Table 1). There were eight treatments that had significantly lower *Verticillium dahliae* mean CFU/g per plot pre-planting (Table 1). Quantitative PCR targeting *V. dahliae* DNA at 55 DAP found that 10 treatments had lower levels of target DNA, indicating less PED colonization in the plant. No RLN was found in treatment plots or in root samples collected at pre-planting (5 May) and at 55 DAP (21 Jul). No phytotoxicity was observed from any treatments.

Table 1. Effects of in-furrow, at planting, and foliar treatments on percent plant emergence, rate of emergence, severity of Verticillium wilt, rate of disease progression, total and marketable yield in hundred-weight per acre, vascular discoloration of tubers, *Verticillium dahliae* colony forming units (CFU) in soil and amount of *V. dahliae* DNA in plant tissue.

Treatment and rate[a,]	Plant stand[b] 34 DAP[c] (%)	RAUEPC[d] 0 – 34 DAP[j]	PED[e] 24 Aug 91 DAP	RAUDPC[f] 0 – 91 DAP[j] (%)[j]	Yield (CWT) Total	US #1	B Size	VD[g] (%)	Average CFU/g of Soil[h] 5 May	TaqMan Assay (Ct-values)[i]
Non-Treated	74.6 abc[j]	0.806 abc	4.9 a	0.037 cde	233.0 abc	174.5 ab	58.4 a-d	70 bcd	47.1 a	33.0 a
TI435 600 SC 4.653 oz/A (C)	76.3 ab	0.801 abc	4.8 ab	0.039 a-d	204.2 a-f	126.4 def	77.8 ab	70 bcd	28.4 abc	23.4 ab
Velum Prime 6.5 oz/A (C) TI435 600 SC 4.653 oz/A (C)	76.8 ab	0.804 abc	4.8 ab	0.039 a-d	212.0 a-f	150.8 a-e	61.2 abc	87 ab	20.4 bc	16.1 b
FLU+CTD 15 oz/A (C)	74.6 abc	0.800 abc	4.4 b	0.037 cde	196.6 b-f	129.9 c-f	66.7 abc	73 bcd	26.4 abc	32.2 a
Velum Prime 6.5 oz/A (C)	69.6 c	0.816 a	4.8 ab	0.039 a-d	173.0 ef	119.4 ef	53.5 cd	83 abc	26.6 abc	31.3 a
Velum Prime 6.5 oz/A (C) Movento HL 2.5 oz/A (E)	74.1 abc	0.806 abc	4.8 ab	0.039 a-d	220.1 a-d	141 b-f	79.1 a	63 d	30.9 abc	15.7 b
Velum Prime 6.5 oz/A (C) Luna Tranquility 11.2 oz/A (D)	76.3 ab	0.795 c	4.8 ab	0.040 abc	228.2 a-d	169.4 abc	58.7 a-d	77 bcd	36.5 ab	31.2 a
Velum Prime 6.5 oz/A (C) Luna Tranquility 11.2 oz/A (D) Movento HL 2.5 oz/A (E)	75.4 abc	0.805 abc	4.9 a	0.040 a-d	187.7 c-f	129.3 c-f	58.4 a-d	63 d	14.5 c	25.6 ab
Velum Prime 6.5 oz/A (C) Luna Tranquility 11.2 oz/A (D) Luna Tranquility 11.2 oz/A (E)	71.4 bc	0.813 ab	4.8 ab	0.042 a	165.6 f	108.7 f	56.8 bcd	80 a-d	30.0 abc	30.6 a
Vydate 310 SL 6.5 oz/A (C) Vydate 310 SL 16 oz/A (D) Vydate 310 SL 16 oz/A (E)	76.8 ab	0.797 bc	4.5 bc	0.038 cde	227.3 a-d	157.2 a-e	70.2 abc	87 ab	25.5 abc	22.2 ab
CruiserMaxx 0.31 oz/CWT (B) Elatus 7.7 oz/A (C)	76.8 ab	0.803 abc	4.8 ab	0.040 abc	225.8 a-d	154.1 a-e	71.7 abc	83 abc	30.0 abc	16.2 b
CruiserMaxx 0.31 oz/CWT (B) Elatus 7.7 oz/A (C) Elatus 7.7 oz/A (D)	74.6 abc	0.803 abc	4.8 ab	0.039 a-d	182.0 def	121.4 ef	60.5 abc	77 bcd	22.4 bc	22.3 ab
CruiserMaxx 0.31 oz/CWT (B) Elatus 7.7 oz/A (D)	73.7 abc	0.795 c	4.9 a	0.041 ab	216.9 a-e	153.3 a-e	63.6 abc	83 abc	26.7 abc	30.5 a
Vapam 45 gal/A (A)	77.2 ab	0.793 c	4.9 a	0.040 a-d	220.7 a-d	153.1 a-e	67.6 abc	73 bcd	20.0 bc	31.5 a
PicPlus 98 lb/A (A)	73.7 abc	0.806 abc	4.4 c	0.035 e	246.8 a	186.3 a	60.5 abc	70 bcd	24.4 bc	22.9 ab
Majestine 1 gal/A (C) Bio-Tam 2.0 2.5 lb/A (C) Majestine 1 gal/A (D) Bio-Tam 2.0 2.5 lb/A (D)	72.8 abc	0.798 bc	4.8 ab	0.039 b-e	224.3 a-d	153.3 a-e	71 abc	73 bcd	32.8 ab	30.9 a

Majestine 1 gal/A (C) Majestine 1 gal/A (D)	77.2 ab	0.794 c	4.8 ab	0.037 de	182.1 def	125.3 def	56.8 bcd	80 a-d	28.0 abc	22.0 ab
MeloCon WG 9 lb/A (C) MeloCon WG 9 lb/A (D) MeloCon WG 9 lb/A (E)	75.4 abc	0.802 abc	4.9 a	0.040 a-d	211.8 a-f	150.9 a-e	60.9 abc	83 abc	22.2 bc	30.3 a
NIMITZ 3.5 pt/A (A)	72.8 abc	0.804 abc	4.8 ab	0.040 a-d	223.1 a-d	165.9 a-d	57.2 bcd	70 bcd	27.1 abc	15.0 b
ADA 58701 7.6 fl oz/A (C)	78.6 a	0.794 c	4.9 a	0.040 abc	239.6 ab	169.7 abc	69.9 abc	80 a-d	31.2 abc	21.1 ab
NIMITZ 3.5 pt/A (A) ADA 58701 7.6 fl oz/A (C)	76.3 ab	0.804 abc	4.9 a	0.040 a-d	191.4 c-f	124.9 def	66.5 abc	67 cd	21.3 bc	30.7 a
NIMITZ 3.5 pt/A (A) NIMITZ 1.5 pt/A (C)	78.1 a	0.806 abc	4.8 ab	0.040 abc	221 a-d	151.9 a-e	69.1 abc	70 bcd	14.0 c	15.0 b
NIMITZ 1.5 pt/A (C)	70.1 bc	0.811 abc	4.8 ab	0.041 ab	172.6 ef	133.4 b-f	39.2 d	97 a	28.5 abc	16.1 b
NIMITZ 3.5 pt/A (A) NIMITZ 1.5 pt/A (C) ADA 58701 7.6 fl oz/A (C)	73.7 abc	0.799 abc	4.9 a	0.039 a-d	217.1 a-e	149.5 a-f	67.6 abc	67 cd	32.3 ab	14.7 b

[a] Application time; A=Pre-planting/pre-plant incorporated; B=Seed treatment; C=In-furrow at planting; D=2” emergence; E=7 Days after 2” emergence.

[b] Plant stand expressed as a percentage of the target population of 120 plants/100ft. row from a sample of 1 x 22 ft rows per plot.

[c] DAP = days after planting on 25 May.

[d] Relative area under the emergence progress curve from planting to 55 days after planting.

[e] PED=Potato Early Die rating using the following scale: 0=No potato early die seen; 1=Small amounts of yellow and flagging of petioles; 2=Moderate amounts of yellowing and flagging of petioles, some of the the flagged petioles becoming necrotic; 3=Symptomatic plants are start to have stems stand straight up while the rest of the plant is laying down, the upright stems are yellow and petioles are wilted and necrotic; 4=Majority of the plot has upright necrotic stems; 5=Entire plot is necrotic, upright stems are brown and petioles are wilted and necrotic, tuber may have brown speckling throughout the stem-end.

[f] Relative area under the disease progress curve from planting to 91 days after planting.

[g] VD=Vascular discoloration of the stem end; percentage calculated from 10 tubers.

[h] CFU=colony forming units seen on selective *Verticillium dahliae* media

[i] Average threshold cycle value of 12 replicates/treatment (within experiment) the higher the Ct value the lower amount of *Verticillium dahlia* target DNA in the sample.

[j] Means followed by same letter are not significantly different at p = 0.10 (Fishers LSD).

Potato (*Solanum tuberosum*) 'Snowden'
Potato Early Blight, Black Dot, White Mold;
Alternaria solani, Colletotrichum coccodes,
Sclerotinia sclerotiorum

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Foliar treatment programs for control of potato early blight, black dot and white mold-Entrican 2017

A field trial was established 25 May (latitude 43°21'9.06"N and longitude - 85°10'30.35"W) at the Montcalm Research Center, Entrican MI to evaluate selected fungicides for early blight, black dot and white mold control (Table 1). US#1 'Snowden' tubers were mechanically cut into approximately 2 oz seedpieces 19 May and allowed to heal before planting. These trials were conducted using potato cultivar 'Snowden' due to its commercial use throughout the state of Michigan and the Midwestern US potato growing region. A randomized complete block design with four replications was used for the experiment, with each plot consisting of two 50-ft-long rows spaced 34 in. apart with tubers 10 in. apart in the row. A 5-ft not-planted alley separated the two-row beds. 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). All were delivered with a hand-held R&D spray boom delivering 10 gal/A (50 p.s.i.) and using one XR8002VR nozzle per row. A non-treated control was compared with 6 different treatment programs to compare their efficacy in controlling potato early blight, black dot and white mold (Table 1). Weeds were controlled by cultivation 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 Sep 21.

Plant stand was rated 20, 35, 42 and 55 days after planting (DAP) and relative rate of emergence was calculated as the Relative Area Under the Emergence Progress Curve [RAUEPC from 0–55 DAP, maximum value = 100]. Plots were not inoculated but relied on natural dispersal of *Alternaria solani, Colletotrichum coccodes* and *Sclerotinia sclerotiorum* for disease establishment. Severity of early blight was rated 61 (25 Jul), 67 (31 Jul), 75 (8 Aug), and 81 (14 Aug) DAP using the Horsfall-Barratt rating scale, and the relative rate of disease progression was calculated as the Relative Area Under the Disease Progress Curve [RAUDPC from 0–81 DAP, maximum value = 100]. Disease severity of black dot was rated incidence of plants/plot infected 21 Aug (88 DAP). Plots (1 x 50-ft row) were machine-harvested on 5 Oct (133 DAP) and individual treatments were weighed and graded.

Meteorological Data

Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Sept. Average daily air temperature (ºF) was 55.0, 68.5, 69.8, 64.9 and 63.5 (May, Jun, Jul, Aug and Sep respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except Sep with 5 days. Average daily relative humidity (%) over the same period was 68.0, 74.6, 74.0, 75.2 and 73.4. Average daily soil temperature at 4" depth (ºF) over the same period was 58.1, 69.4, 71.3, 70.2 and 69.8. Average daily soil moisture at 4" depth (% of field capacity) over the same period was 12.4, 14.0, 9.4, 6.7 and 7.3. Precipitation (in.) over the same period was 1.98, 6.37, 0.92, 1.36 and 0.7". Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period with overhead sprinkle irrigation.

Results

The 2017 growing season provided environmental extremes of excessive moisture early in the season and moisture stress at other times. However, a prolonged period of unusually dry weather continuing from early Jul to mid-Aug resulted in environmental conditions that were not conducive to white mold establishment and development. No treatments were significantly different in percent plant emergence or rate of emergence (RAUEPC). All treatments had significant lower early blight severity at 81 DAP (Aug 14) compared to the non-treated control except for treatments with numbered product MBI-10612 applied at 10% bloom (32 fl oz/A), and Double Nickel LC applied at 10% bloom and 7-10 days post 10% bloom (32 fl oz/A: Table 1). The RAUDPC value of early blight for all treatments was significantly lower than the non-treated control. There was no significant difference in black dot incidence at 81 DAP (Aug 14) except for treatments with numbered product MBI-110AF5 applied at 10% bloom (64 fl oz/A), and MBI-110AF5 at 10% bloom (64 fl oz/A) and 7-10 days post 10% bloom (32 fl oz/A) which were significantly lower than the non-treated control. There were no differences in total and marketable yield (CWT) compared to the non-treated control, however there were significant differences among three treatments (Table 1). These included the treatments with numbered product MBI-110AF5 (32 fl oz/A and 64 fl oz/A) applied at 10% bloom, and Double Nickel LC (32 fl oz/A) applied at 10% bloom and 7-10 days post 10% bloom (Table 1). Similarly, for yield of US#1 (CWT) there was no significant difference among treatments compared to the non-treated control, but there were significant differences among three treatments (Table 1) These included the treatments with numbered product MBI-110AF5 (32 fl oz/A and 64 fl oz/A) applied at 10% bloom, and MBI-10612 applied at 10% bloom (32 fl oz/A: Table 1). For yield of B-size tubers (CWT) the treatment with Double Nickel LC applied at 10% bloom and 7-10 days post 10% bloom (32 fl oz/A) was significantly higher than the non-treated control, all other treatments were not significantly different from the non-treated control. No phytotoxicity was observed from any treatments.

Table 1. Effects of foliar treatments on percent plant emergence, rate of emergence, severity of early blight, rate of disease progression, black dot incidence, and total and marketable yield in hundred-weight per acre.

Treatment, rate and application time	Plant stand[a] 55 DAP[b] (%)	RAUEPC[c] 0 – 55 DAP	EB[d] (%) 14 Aug 81 DAP[e]	RAUDPC[f] 0 – 81 DAP (%)[e]	BD[g] Incidence 81 DAP[e]	Yield (CWT)[e] Total	US #1	B Size
Non-Treated	82.8	0.339	12.0 a	0.105 a	20.3 a	217.3 ab	151.8 ab	65.4 b
Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10	87.5	0.343	9.6 bc	0.050 b	15 abc	222.5 ab	149.0 ab	73.5 ab
Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10 MBI-110AF5 32 fl oz/A at 10% bloom	87.8	0.372	9.4 bc	0.048 b	19.8 ab	195.7 b	124.5 b	71.2 ab
Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10 MBI-110AF5 64 fl oz/A at 10% bloom	89.0	0.360	8.4 c	0.050 b	13.8 c	240.7 a	167.3 a	73.4 ab
Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10 MBI-10612 32 fl oz/A at 10% bloom	81.3	0.342	9.8 abc	0.055 b	16.5 abc	221.5 ab	154.4 a	67.1 b
Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10 MBI-110AF5 64 fl oz/A at 10% bloom MBI-110AF5 32 fl oz/A 7-10 days post 10% bloom	88.0	0.364	9.4 bc	0.058 b	14 bc	221.4 ab	148.9 ab	72.6 ab

Manzate Pro-Stick 2 lb/A at wks. 4,6,8,10 Reason 500C 5.5 fl oz/A at wks 4,5 Bravo WS 2 pt/A at wks 5,7,9,11,13 Luna Tranquility 11.2 fl oz/A at wks 8,9,12 Scala SC 7 fl oz/A at wks. 10 Double Nickel LC 32 fl oz/A at 10% bloom and 7-10 days post 10% bloom	87.5	0.357	11.3	ab	0.056	b	14.5	abc	230.3	a	148.2	ab	82.1 a

[a] Plant stand expressed as a percentage of the target population of 120 plants/100ft. row from a sample of 1 x 50 ft rows per plot.
[b] DAP = days after planting on 25 May.
[c] Relative area under the emergence progress curve from planting to 55 days after planting.
[d] EB=Early blight rating using severity rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage and stems dead). Ratings were converted to percentages.
[e] Means followed by same letter are not significantly different at $p = 0.10$ (Fishers LSD).
[f] Relative area under the disease progress curve from planting to 81 days after planting.
[g] BD=Black dot (*Colletotrichum coccodes*) incidence.

Potato (*Solanum tuberosum*)
Verticillium wilt; *Verticillium dahliae*

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In-vitro sensitivity distributions of *Verticillium dahliae* isolates from potato to sedaxane, solatenol, difenoconazole and fludioxonil 2017

Verticillium wilt caused by the fungus *Verticillium dahliae* is an annual production concern for potato growers in Michigan and throughout the USA. Levels of *V. dahliae* colony forming units (CFU) in the soil have a direct correlation with level of observed disease severity in above ground plant parts, so managing CFU in the soil is the common practice in commercial potato production. Historically, growers have relied on strict soil fumigation regimes to decrease *V. dahliae* propagules in the soil, but these soil fumigation programs can be cost prohibitive. Furthermore, the negative impact that these fumigants can have on the environment, coupled with growing concern over their impact on beneficial microorganisms in the soil has led to an increased focus on the development of alternative management strategies for Verticillium wilt. The results of experimental field trials from 2013-2016 (Appendix I) provided baseline information on the effects of several commercially available fungicides and their ability to manage Verticillium wilt of potato. Initial comparison of seven fungicides found that pyramethanil + fluopyram (Luna Tranquility, Bayer CropScience) when applied in-furrow at planting significantly decreased disease severity and CFU in the stem were reduced but had no effect on CFU units in the soil. Similarly, applying pyramethanil + fluopyram at emergence may decrease disease severity and CFU in the stem.

Whether these results are due to inhibition of *V. dahliae* in the stem by pyramethanil + fluopyram or a reduction of root-lesion nematodes (RLN) in the soil are yet to be elucidated. Though the cause of the reduction in CFU in the stem and disease severity is not yet known, it is apparent that pyramethanil + fluopyram is useful in managing Verticillium wilt. The objective of this study is to determine if the effect of fungicide on microsclerotial germination and sensitivity *in vitro* is contributing to the observed control of Verticillium wilt in the field.

Sample collection and geographical origin of isolates: Isolates of *V. dahliae* were collected from soil in Michigan and obtained from culture collections of collaborating universities. A total of 8 isolates were used in the study. Isolates were received from the following potato production states: Idaho (1 isolate), Michigan (2 isolates), North Dakota (4 isolates), and Washington (1 isolates). Monoconidial isolates were obtained by sub-culturing a single conidium of *V. dahliae* onto Czapek-Dox Agar.

In vitro sensitivity by gradient plating of *Verticillium dahliae* isolates to sedaxane, solatenol, difenoconazole and fludioxonil: Difenoconazole, solatenol, sedaxane, and fludioxonil stock solutions of 10,000 mg/liter of each fungicide are prepared by dissolving commercial-grade fungicides in a sterile solvent. 50 ml of Czapek-Dox Agar was poured into each dish, to form a layer of agar with a known constant volume, thus when a stock solution is added to the agar results in a gradient from 0 to 1000 mg/liter across the surface. A method using a spiral gradient plater (Figures 1 and 2) was used to determine effective concentration in inhibiting growth by 50% (EC_{50}). Pure cultures of *V. dahliae* were prepared as described above and used in sensitivity assays. Conidial suspensions were prepared by flooding colony Petri dishes with 200 mL distilled water and scraping the conidia free from the surface with a rubber policeman. The conidial suspension (10 mL) was spread across the fungicide gradient plate from edge to center. The point coordinates at which the colonies start and end was recorded and entered into a software program, which calculates the EC_{50} for each isolate.

Results: The individual isolate and mean EC_{50} values were estimated for each of the fungicides listed above. A total of eight isolates were screened against the fungicides difenoconazole, solatenol, sedaxane, and fludioxonil respectively (Table 1). For difenoconazole, solatenol, sedaxane, and fludioxonil the mean EC_{50} values (mg/liter) were 11.01, 14.90, 43.28, and 92.41 respectively (Table 1). The distribution of *V. dahliae* isolate sensitivity in EC_{50} values (mg/L) for all fungicides tested ranged from >1 to 105 (Table 1 and Figure 3). Additionally, while there was a differential response to difenoconazole, solatenol, sedaxane, and fludioxonil insofar as the sensitivity of each isolate, there was an observable isolate/fungicide dependent difference in the formation of microsclerotia in-vitro (Figures 1 and 2).

Ongoing and future directions: Currently we are comparing the accuracy and precision of the spiral gradient method to traditional dilution agar plating in determining fungicide sensitivity. We will use the same isolates used in the spiral planting assay to test for sensitivity to difenoconazole, solatenol, sedaxane, and fludioxonil. Additionally, further testing of the ability to produce and the viability of mircosclerotia on fungicide amended agar may be warranted. Future research should attempt to understand the temporal effect that fungicide applications are having on RLN and whether this interaction is contributing to a decrease in Verticillium wilt symptoms when fungicide treatments are applied to potato in-furrow and at emergence.

Table 1. Comparison of mean effective concentration in growth by 50% (EC_{50}) for isolates of ***Verticillium dahliae*** to difenoconazole, solatenol, sedaxane, and fludioxonil.

		EC_{50} (mg/L)[a,b]			
Isolate	**Origin**	**DFX**	**STL**	**SDX**	**FDL**
49.B.2010	WA	0.97	37.75	72.97	105.00
UM1	ND	4.31	0.99	40.93	4.25
UM2	ND	37.42	37.75	51.93	105.00
H5	ND	37.42	37.75	1.91	105.00
MN3D	ND	5.05	1.83	2.11	105.00
V1	MI	0.97	1.12	40.93	105.00
V3	MI	0.97	0.99	105.00	105.00
V18	MI	0.97	0.99	30.49	105.00
Mean		11.01	14.90	43.28	92.41

[a] EC50 values determined for two replications based on mean effective concentration in growth by 50% by spiral gradient dilution method.
[b] Difenoconazole=DFZ; solatenol=STL; sedaxane=SDX and fludioxonil=FDL.

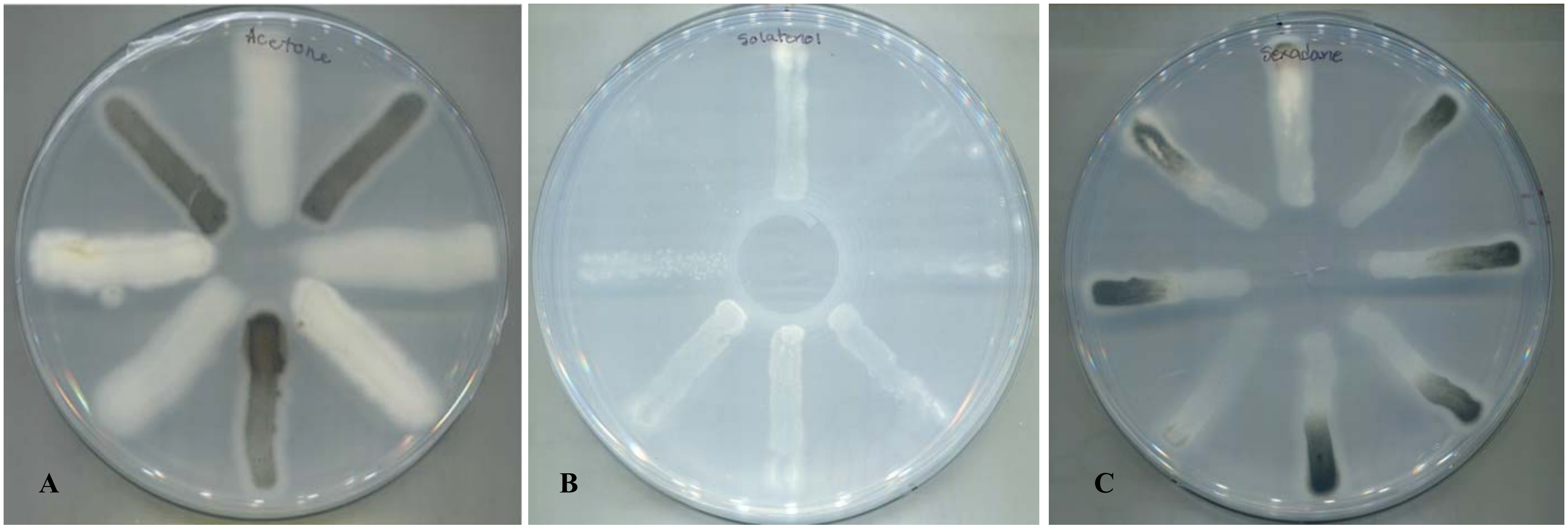


Figure 1. Growth of ***Verticillium dahliae*** (isolates placed on the same position on the plate) isolates from spiral plate dilution gradient assay on non-fungicide amended plate (A), solatenol plate (B) and sedaxane (C).

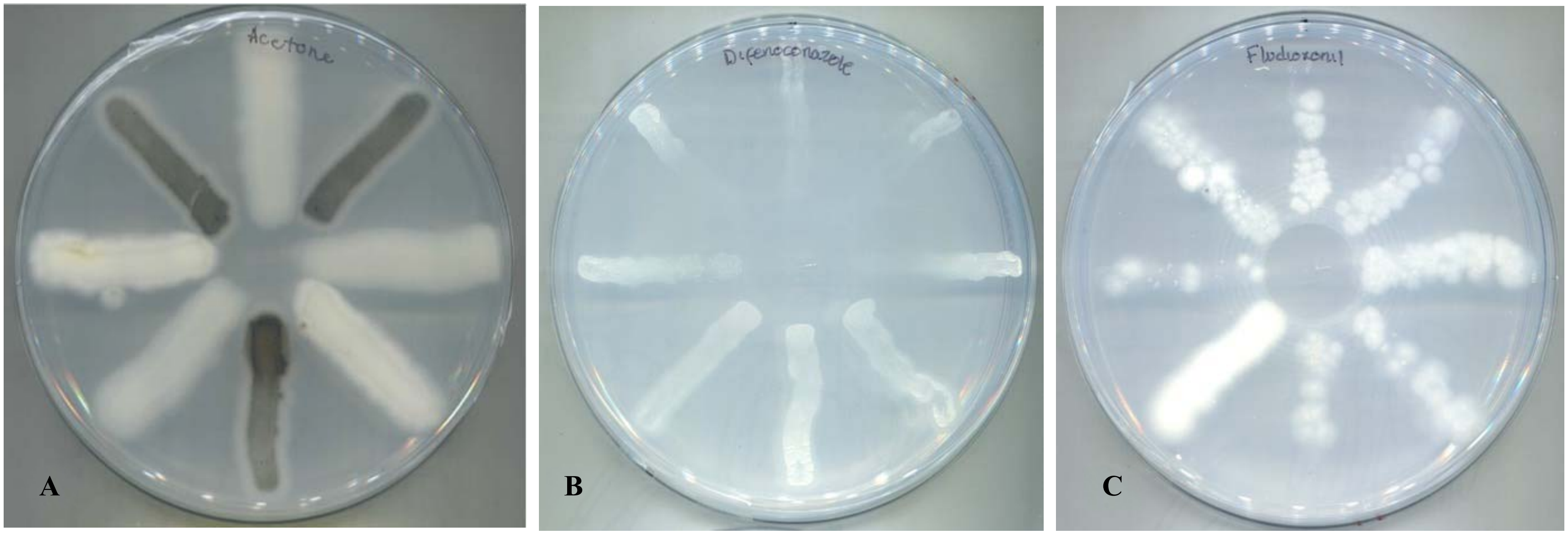
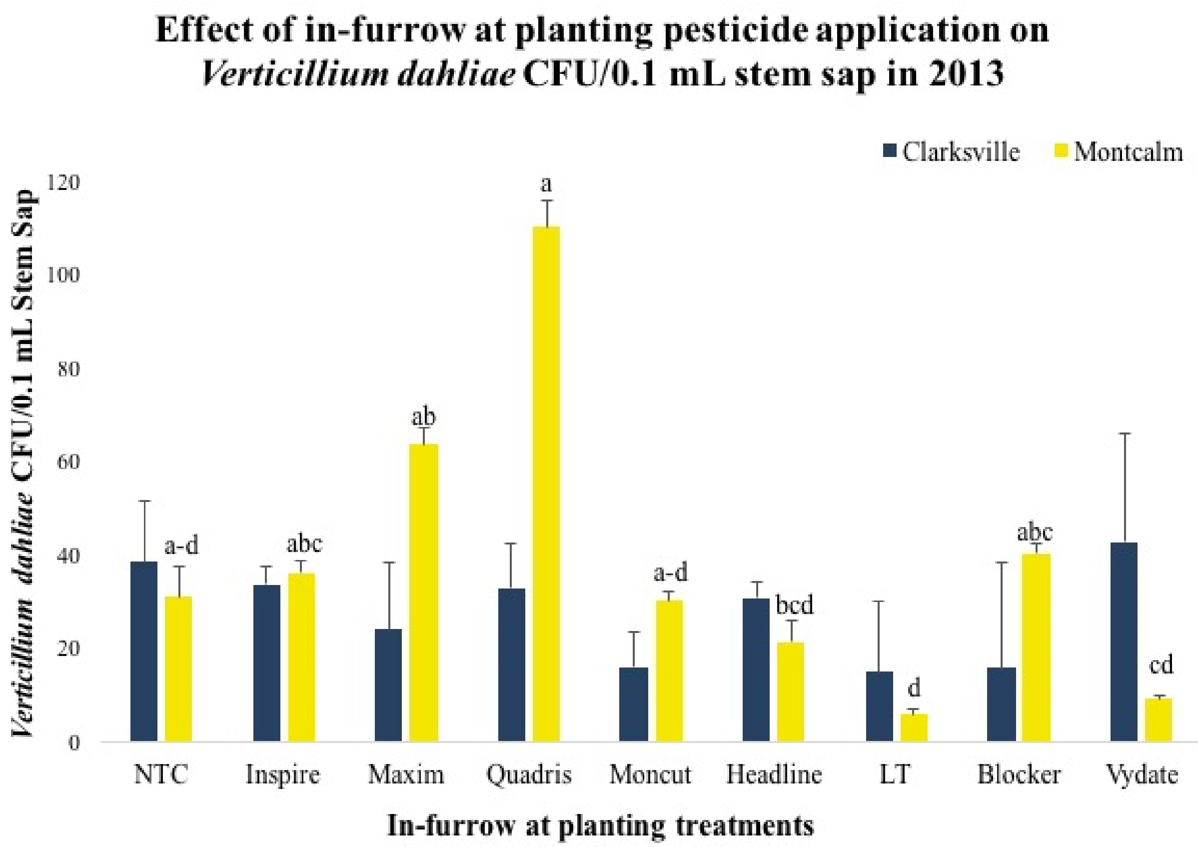
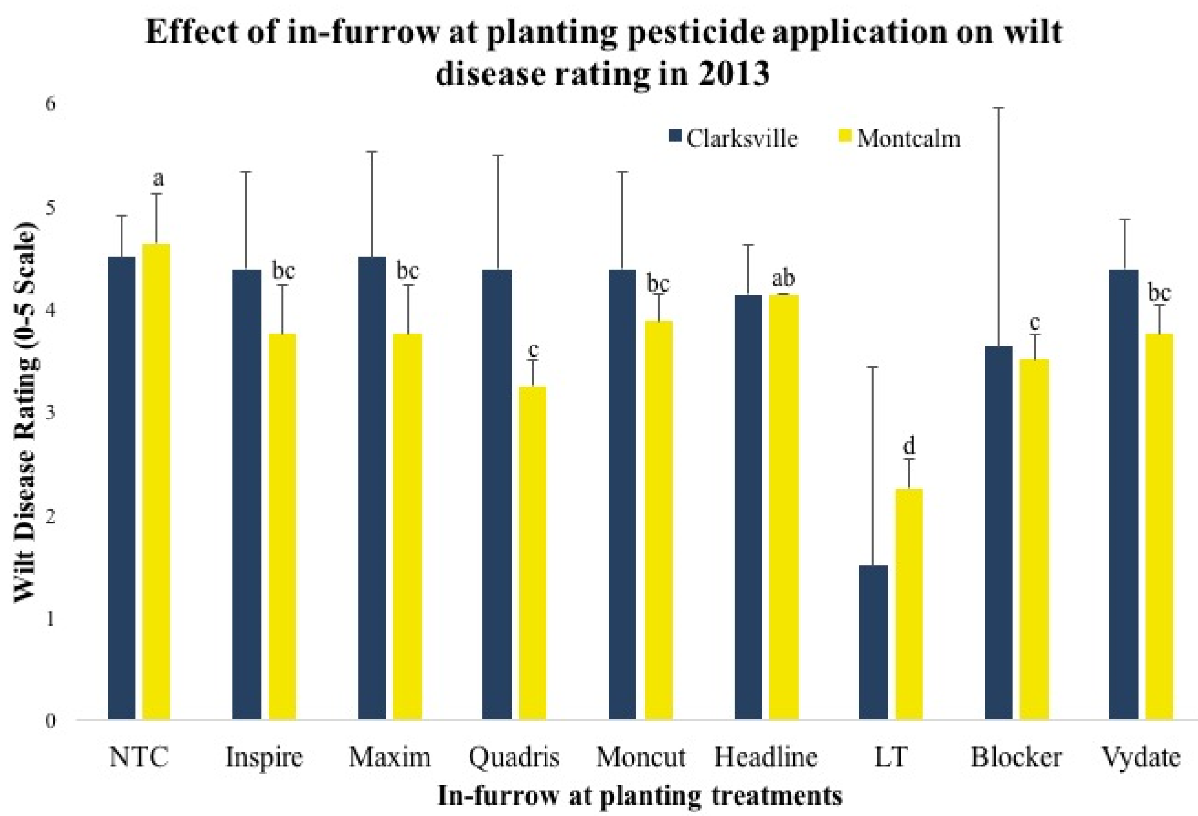


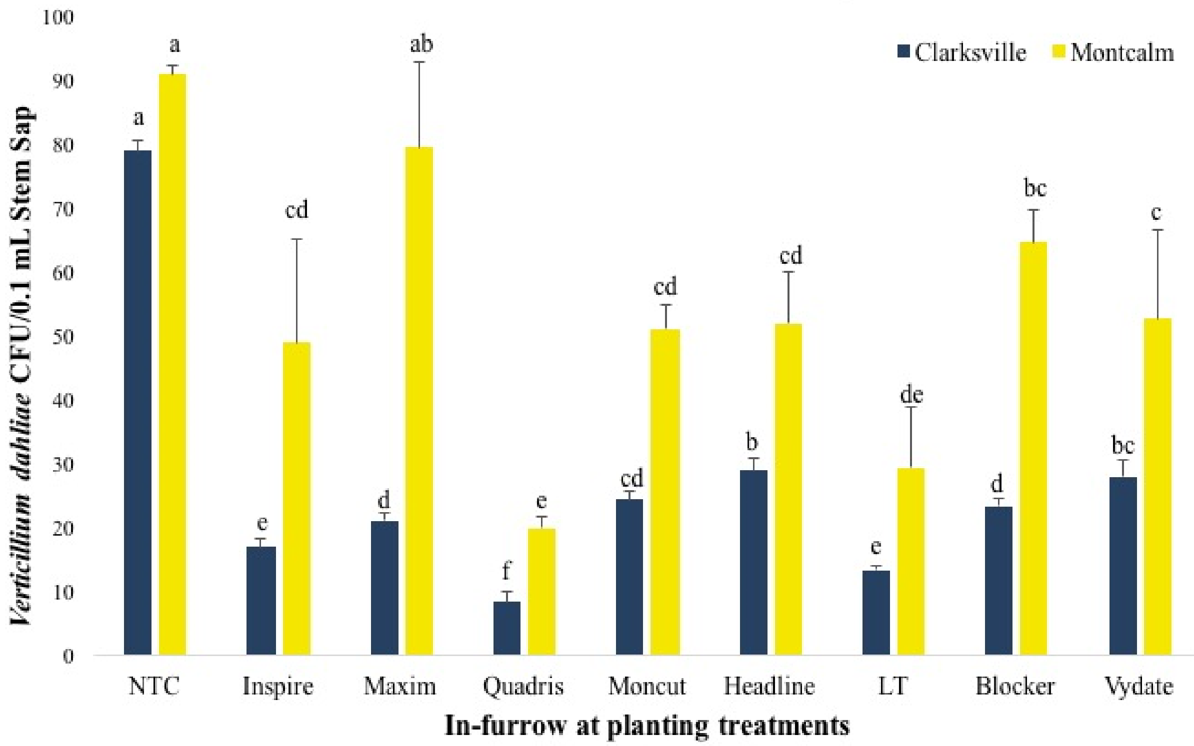
Figure 1. Growth of ***Verticillium dahliae*** (isolates placed on the same position on the plate) isolates from spiral plate dilution gradient assay on non-fungicide amended plate (A), difenoconazole plate (B) and fludioxonil (C).

Appendix I

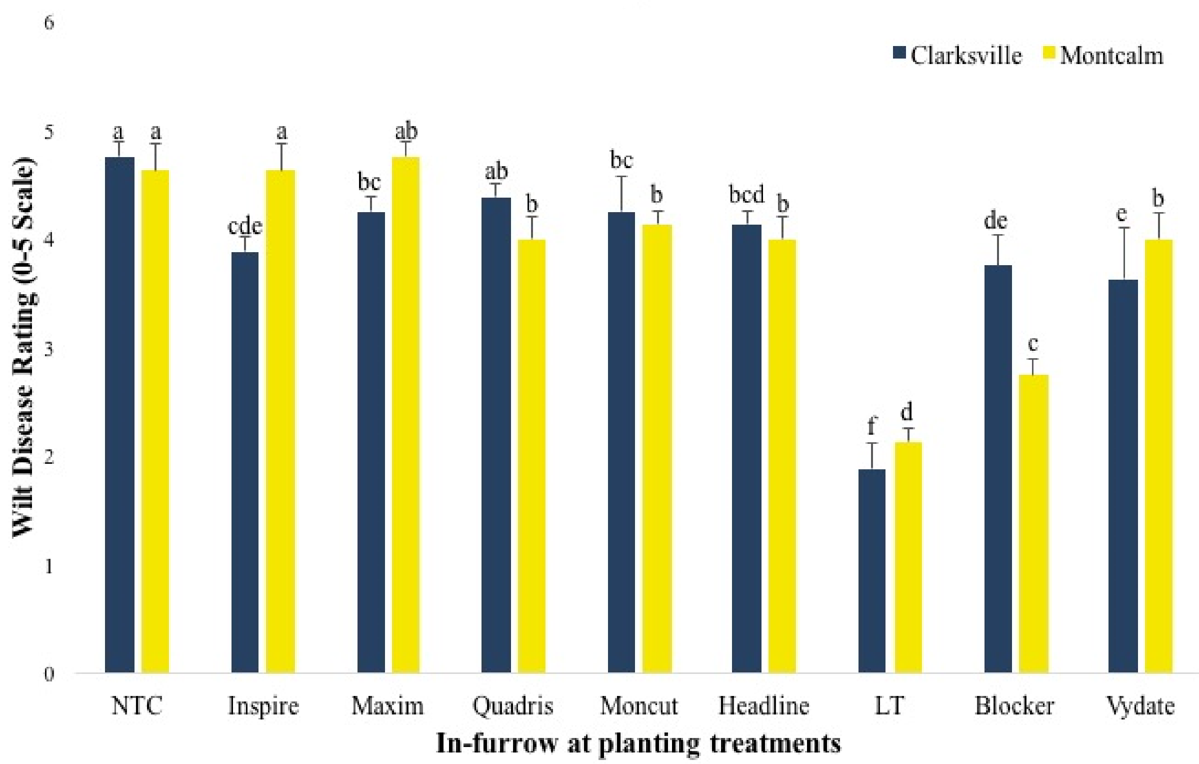

Effect of in-furrow at planting pesticide application on
Verticillium dahliae CFU/0.1 mL stem sap in 2013
Clarksville
Montcalm
Verticillium dahliae CFU/0.1 mL Stem Sap
120
100
80
60
40
20
0
a-d
abc
ab
a
a-d
bcd
d
abc
cd
NTC
Inspire
Maxim
Quadris
Moncut
Headline
LT
Blocker
Vydate
In-furrow at planting treatments


Effect of in-furrow at planting pesticide application on wilt disease rating in 2013
Clarksville
Montcalm
Wilt Disease Rating (0-5 Scale)
6
5
4
3
2
1
0
a
bc
bc
c
bc
ab
d
c
bc
NTC
Inspire
Maxim
Quadris
Moncut
Headline
LT
Blocker
Vydate
In-furrow at planting treatments

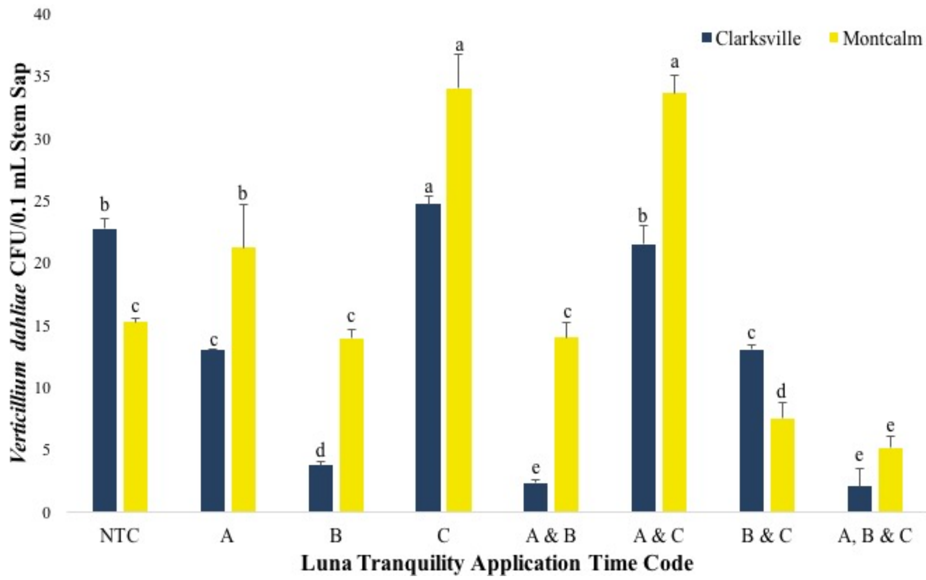
Effect of in-furrow at planting pesticide application on *Verticillium dahliae* CFU/0.1 mL stem sap in 2014



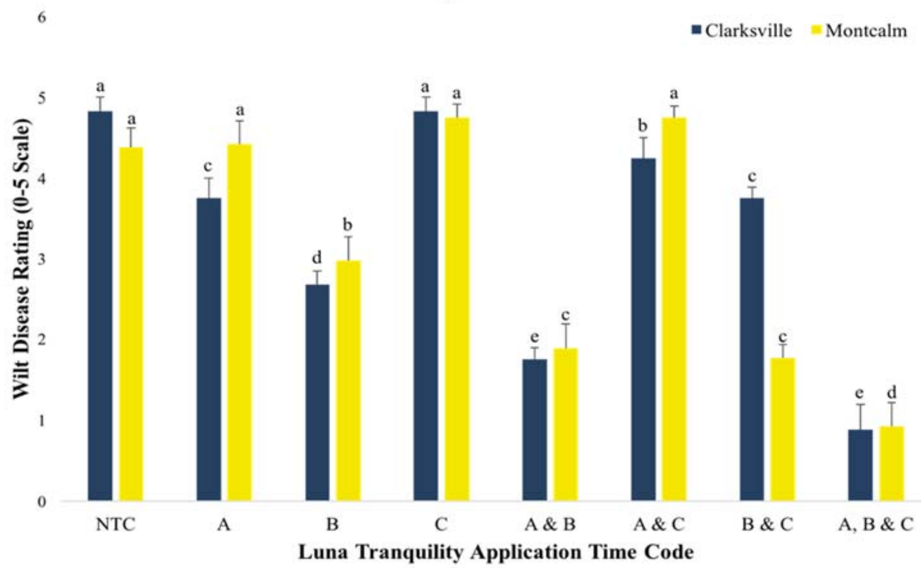
Effect of in-furrow at planting pesticide application on wilt disease rating in 2014



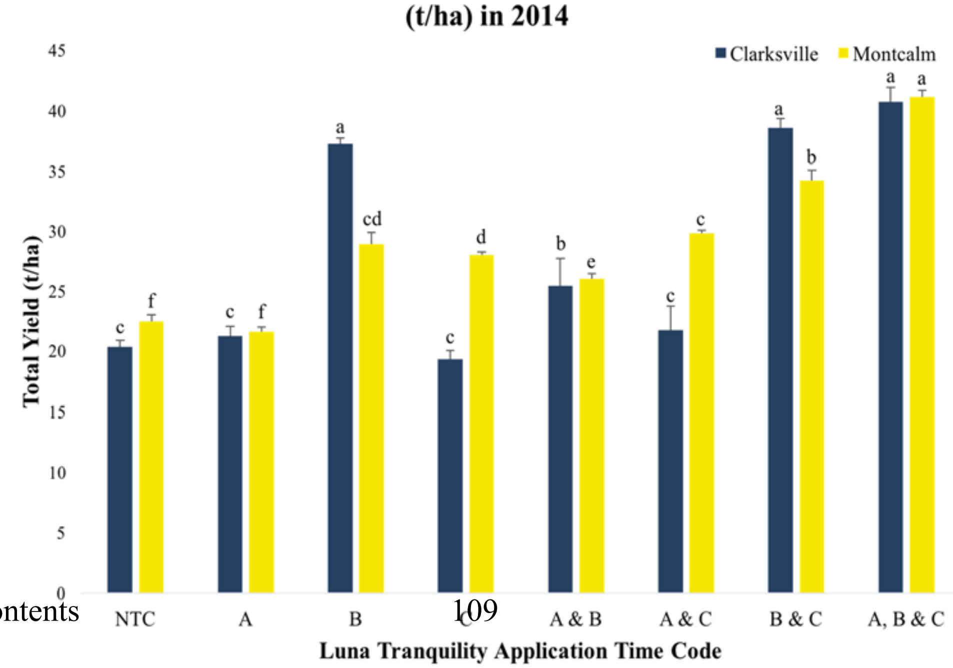
Effect of application time of Luna Tranquility on *Verticillium dahliae* CFU recovered/0.1 mL stem sap in 2014

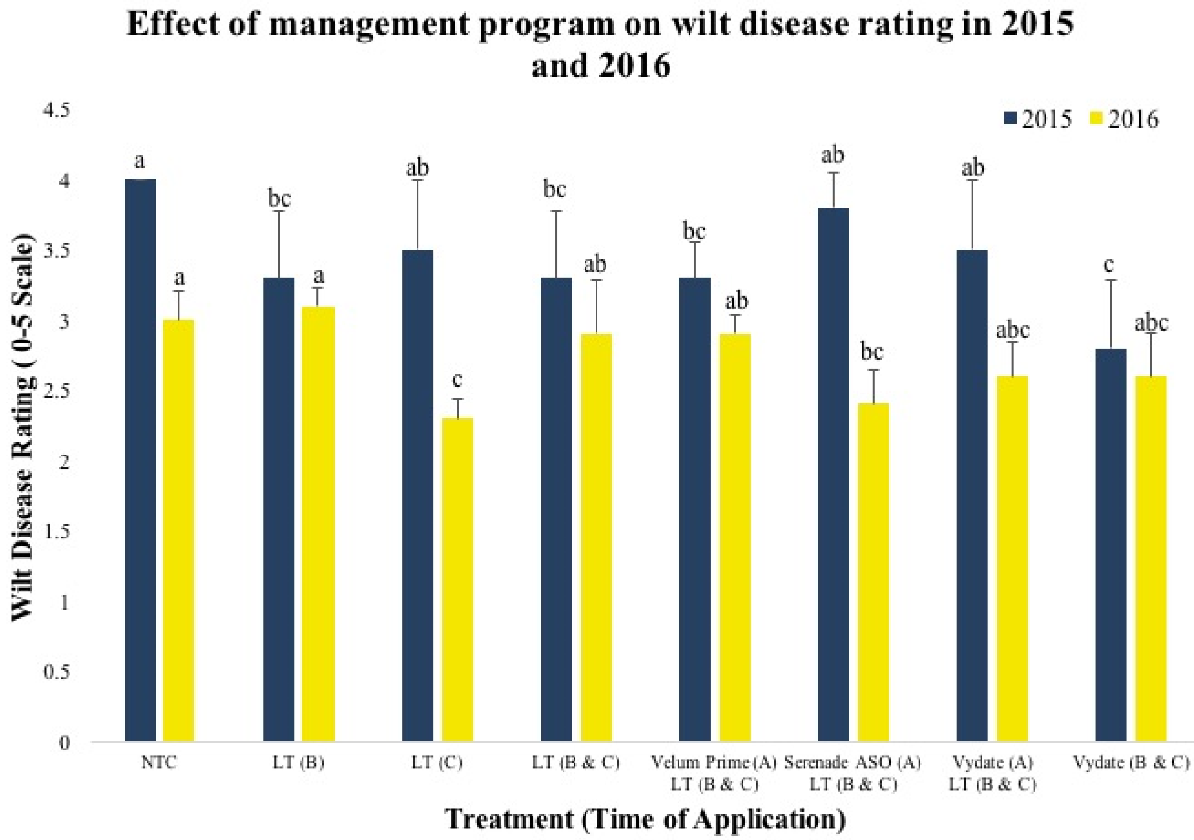


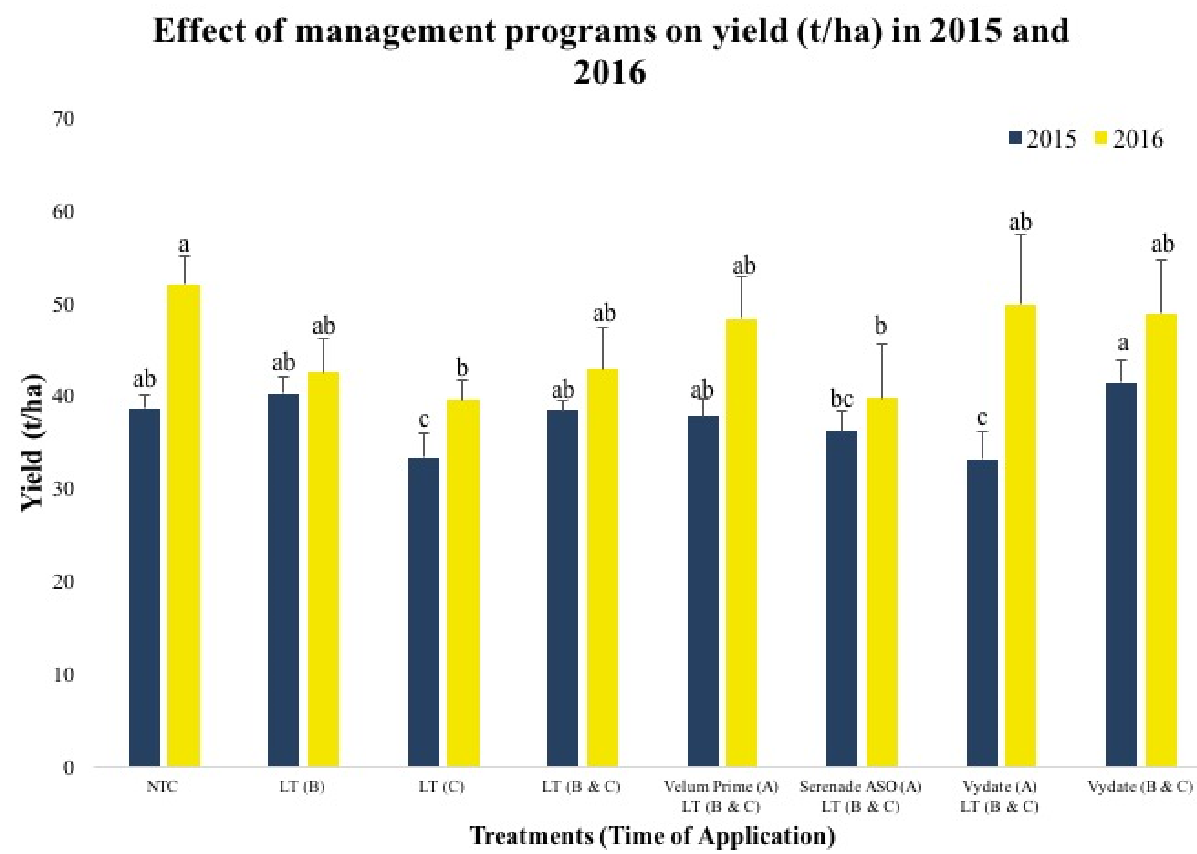
Effect of application time of Luna Tranquility on wilt disease rating in 2014



Effect of application time of Luna Tranquility on total yield (t/ha) in 2014




Effect of management program on wilt disease rating in 2015 and 2016
2015
2016
Wilt Disease Rating (0-5 Scale)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
a
a
bc
a
ab
c
bc
ab
bc
ab
ab
bc
ab
abc
c
abc
NTC
LT (B)
LT (C)
LT (B & C)
Velum Prime (A) LT (B & C)
Serenade ASO (A) LT (B & C)
Vydate (A) LT (B & C)
Vydate (B & C)
Treatment (Time of Application)


Effect of management programs on yield (t/ha) in 2015 and 2016
2015
2016
Yield (t/ha)
70
60
50
40
30
20
10
0
ab
a
ab
ab
c
b
ab
ab
ab
ab
bc
b
c
ab
a
ab
NTC
LT (B)
LT (C)
LT (B & C)
Velum Prime (A) LT (B & C)
Serenade ASO (A) LT (B & C)
Vydate (A) LT (B & C)
Vydate (B & C)
Treatments (Time of Application)

Potato (*Solanum tuberosum*)
Silver Scurf; *Helminthosporium solani*

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In-vitro sensitivity distributions of *Helminthosporium solani* isolates to sedaxane, solatenol, difenoconazole and fludioxonil from potato 2017

Silver scurf caused by *Helminthosporium solani* is a persistent problem for potato production and is of particular importance in temperate regions. Additionally, the disease is common in potato seed tubers and can become an issue in storage. For example, in Michigan where 70% of potato production is for chip stock the ability to store potatoes for longer is particularly important. Moreover, growers are able to store potatoes for longer periods, which may exacerbate marketability problems associated with silver scurf. Therefore, effective chemistries for management of the disease in storage is essential. Additionally, determining the risk of reduced sensitivity to available products labeled for silver scurf will increase the long-term efficacy of these fungicides.

Sample collection and geographical origin of isolates: Isolates of *H. solani* were collected from harvested potatoes in 2016 and obtained from culture collections of collaborating universities. A total of 73 isolates were used in the study. Isolates from harvested stored potatoes were collected from potatoes grown in the following potato production states: Idaho (23 isolates), Michigan (9 isolates), Oregon (30 isolates), and Wisconsin (11 isolates).

Representative tubers were randomly selected from potato storages, lightly washed to remove soil, and placed into standard 5 kg capacity wicket poly bags with several rows of 7 mm diameter holes that are used to market fresh potatoes. The bags were placed into boxes and stored for 3 weeks at 20°C in the dark to promote sporulation. Boxes and bags were opened weekly and tubers lightly moistened with water using a standard hand-pump spray bottle to maintain relative humidity near 100 %. Monoconidial isolates from individual tubers were obtained by sub-culturing a single conidium of *H. solani* onto clarified V8 (CV8) media amended with CaCO3 (900 ml of distilled H2O, 100 ml of CV8, 15 g of Bacto Agar, and 1.5 g of CaCO3).

In vitro sensitivity by gradient plating of *Helminthosporium solani* isolates to sedaxane, solatenol, difenoconazole and fludioxonil: Difenoconazole, solatenol, sedaxane, and fludioxonil stock solutions of 10,000 mg/liter of each fungicide are prepared by dissolving commercial-grade fungicides in a sterile solvent. 50 ml of CV8 agar was poured into each dish, to form a layer of CV8 agar with a known constant volume, thus when a stock solution is added to the agar results in a gradient from 0 to 1000 ppm across the surface. A method using a spiral gradient plater (Figures 1 and 2) was used to determine effective concentration in inhibiting growth by 50% (EC_{50}). Pure cultures *H. solani* were prepared as described above. Conidial suspensions are prepared by flooding colony Petri dishes with 200 mL distilled water and scraping the conidia free from the surface with a rubber policeman. The conidial suspension (10 mL) was spread across the fungicide gradient plate from edge to center. Isolates were incubated for 2 weeks, at 24°C (two replications). The point coordinates at which the colonies start and end was recorded and entered into a software program, which calculates the EC_{50} for each isolate for each of the fungicides.

Results

The mean EC_{50} values were estimated for each of the fungicides listed above. A total of 26, 33, 33, and 34 isolates were screened against the fungicides difenoconazole, solatenol, sedaxane, and fludioxonil respectively (Table 1). For difenoconazole, solatenol, sedaxane, and fludioxonil the mean EC_{50} values were 13.91, 9.48, 9.68, and 45.82 respectively (Table 1). The distribution of *Helminthosporium solani* isolate sensitivity in EC_{50} values (mg/L) for all fungicides tested ranged from <1 to >100 (Table 1 and Figure 3).

Ongoing and future directions:

Currently we are comparing the accuracy and precision of the spiral gradient method to traditional dilution agar plating in determining fungicide sensitivity. We have recovered additional isolates from potatoes in storage from the 2016 growing season that will be tested for sensitivity to difenoconazole, solatenol, sedaxane, and fludioxonil. Additionally, we will collect isolates stored from the 2017 growing season that we will test for sensitivity to difenoconazole, solatenol, sedaxane, and fludioxonil.

Table 1. Comparison of mean effective concentration in growth by 50% (EC_{50}) for isolates of *Helminthosporium solani* to difenoconazole, solatenol, sedaxane, and fludioxonil.

			EC_{50} (mg/L)[a]		
Active ingredient	**FRAC[b] code**	**Total # of isolates**	**Mean (s.e.)[c]**	**Minimum**	**Maximum**
Difenoconazole	3	26	13.91 ± 4.3	0.10	77.64
Solatenol	7	33	9.48 ± 6.5	0.10	105.00
Sedaxane	7	33	9.68 ± 3.61	0.10	65.88
Fludioxonil	12	34	45.82 ± 8.09	0.10	105.00

[a] EC50 values determined for two replications based on mean effective concentration in growth by 50% by spiral gradient dilution method

[b] FRAC=Fungicide Resistance Action Committee group name based on chemical relatedness and mode of action

[c] s.e.=standard error of the mean

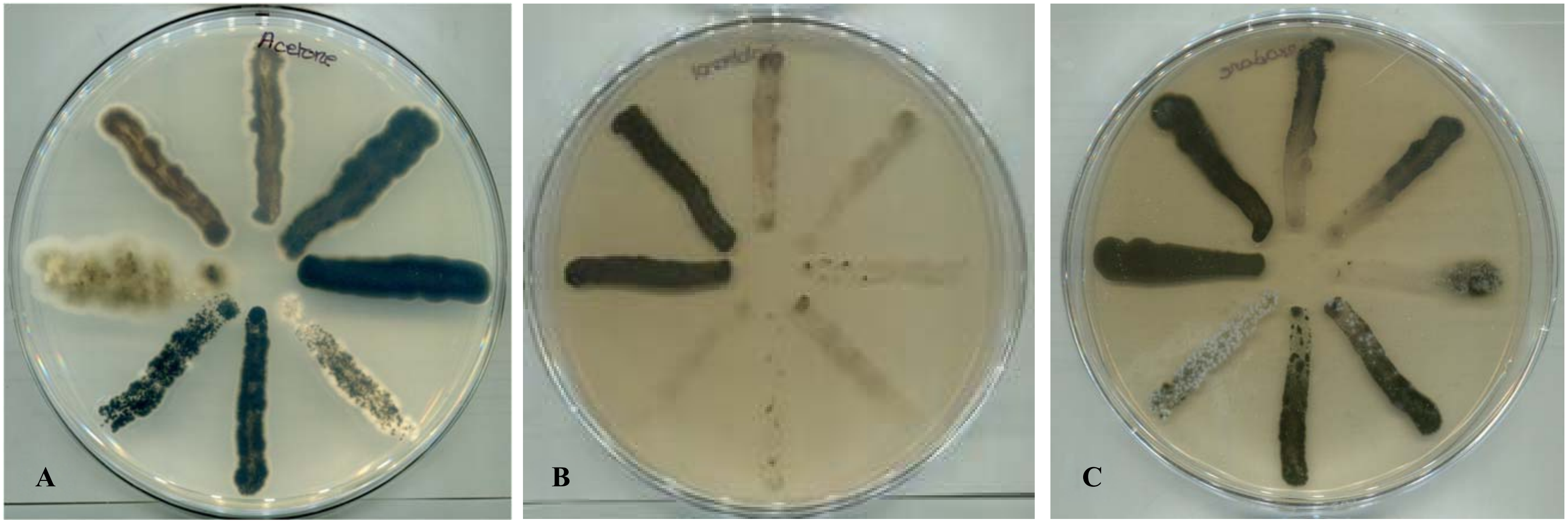

Figure 1. Growth of *Helminthosporium solani* (isolates placed on the same position on the plate) isolates from spiral plate dilution gradient assay on non-fungicide amended plate (A), solatenol plate (B) and sedaxane (C).

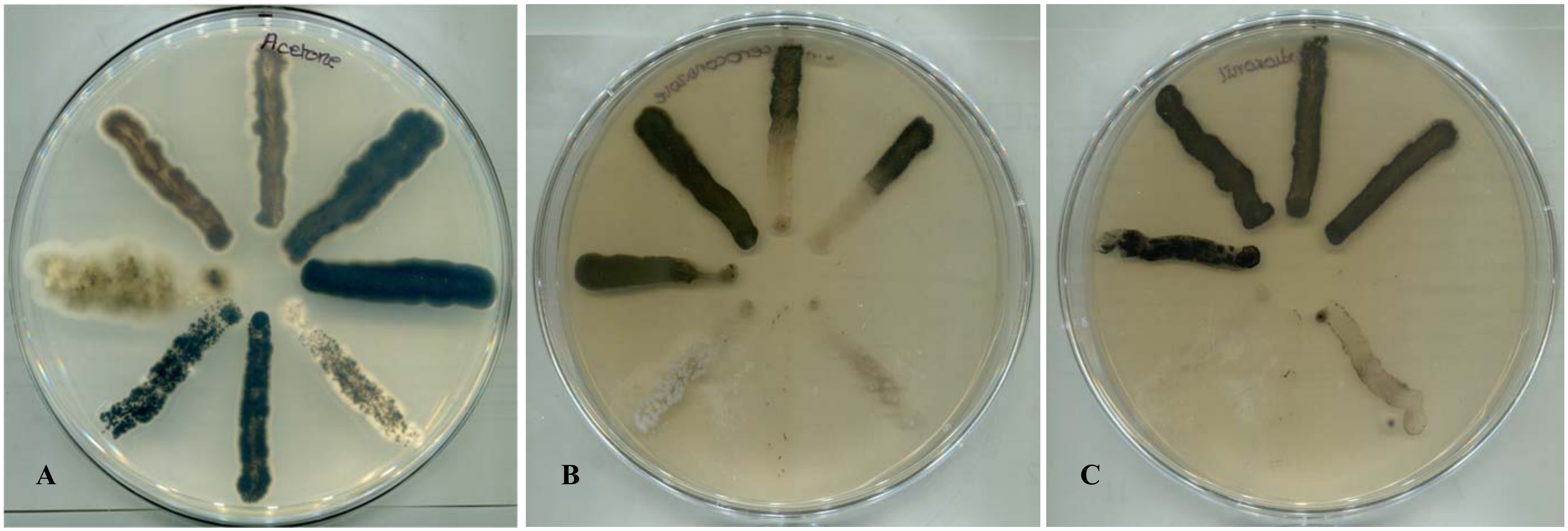

Figure 1. Growth of *Helminthosporium solani* (isolates placed on the same position on the plate) isolates from spiral plate dilution gradient assay on non-fungicide amended plate (A), difenoconazole plate (B) and fludioxonil (C).

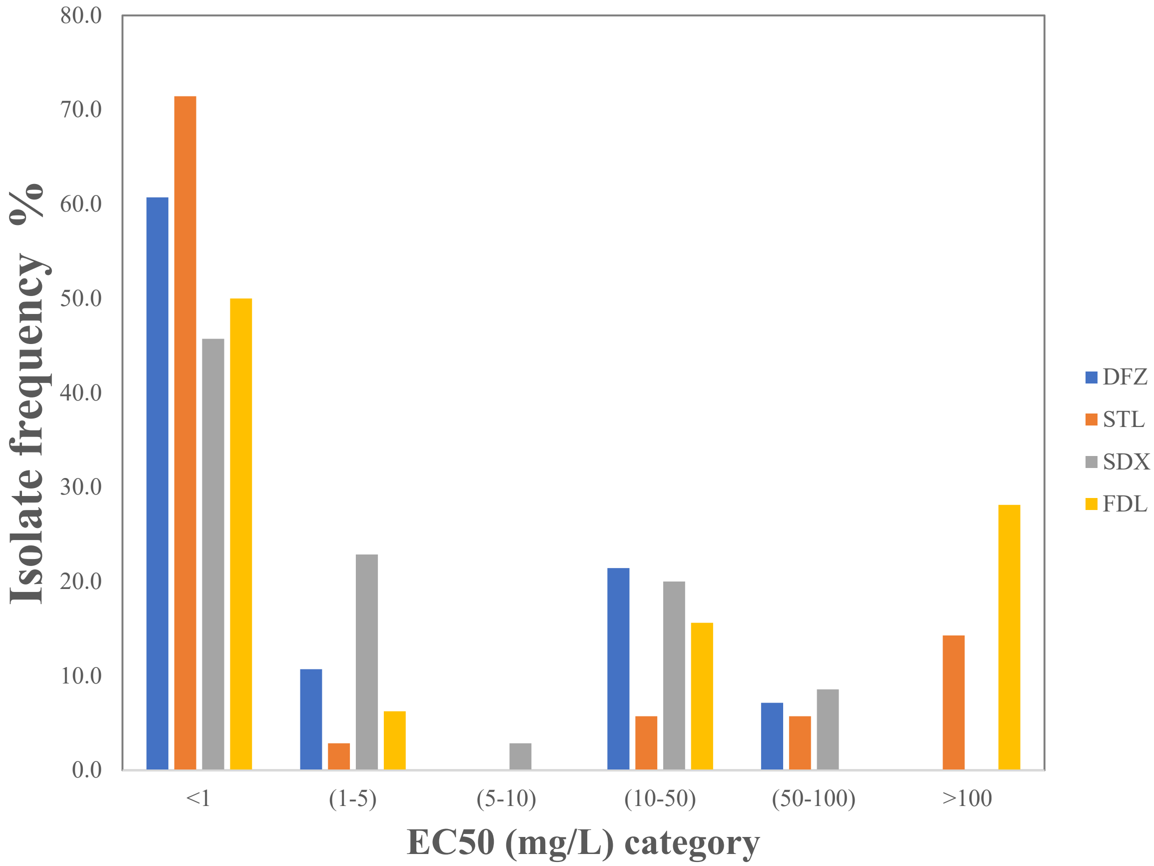

Figure 3. Frequency distributions of in vitro sensitivity of *Helminthosporium solani* isolates collected in 2016 from potato tubers. Sensitivity expressed as 50% inhibition of fungal growth (EC_{50}) in vitro, fungicide concentration estimate based determined by the spiral gradient dilution method. Difenoconazole=DFZ; solatenol=STL; sedaxane=SDX and fludioxonil=FDL.

Potato (*Solanum tuberosum*)
Verticillium wilt; *Verticillium dahliae*

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East Lansing, MI 48824

In vitro assay to assess efficacy of fluopyram for inhibition of *Verticillium dahliae* conidial germination 2017

Verticillium wilt caused by the fungus *Verticillium dahliae* is an annual production concern for potato growers in Michigan and throughout the USA. Levels of *V. dahliae* colony forming units (CFU) in the soil have a direct correlation with level of observed disease severity in above ground plant parts, so managing CFU in the soil is the common practice in commercial potato production. Historically, growers have relied on strict soil fumigation regimes to decrease *V. dahliae* propagules in the soil, but these soil fumigation programs can be cost prohibitive. Furthermore, the negative impact that these fumigants can have on the environment, coupled with growing concern over their impact on beneficial microorganisms in the soil has led to an increased focus on the development of alternative management strategies for Verticillium wilt. The results of experimental field trials from 2013-2016 (Appendix 1) provided baseline information on the effects of several commercially available fungicides and their ability to manage Verticillium wilt of potato. Initial comparison of seven fungicides found that pyramethanil + fluopyram (Luna Tranquility, Bayer CropScience) when applied in-furrow at planting significantly decreased disease severity and CFU in the stem were reduced but had no effect on CFU units in the soil. Similarly, applying pyramethanil + fluopyram at emergence may decrease disease severity and CFU in the stem.

Whether these results are due to inhibition of *V. dahliae* in the stem by pyramethanil + fluopyram or a reduction of root-lesion nematodes (RLN) in the soil are yet to be elucidated. Though the cause of the reduction in CFU in the stem and disease severity is not yet known, it is apparent that pyramethanil + fluopyram is useful in managing Verticillium wilt. The objective of this study is to determine if the effect of pyramethanil + fluopyram on microsclerotial germination *in vitro* is contributing to the observed control of Verticillium wilt in the field.

Sample collection and geographical origin of isolates: Isolates of *V. dahliae* were collected from soil in Michigan and obtained from culture collections of collaborating universities. A total of 8 isolates were used in the study. Isolates were received from the following potato production states: Idaho (1 isolate), Michigan (2 isolates), North Dakota (4 isolates), and Washington (1 isolates). Monoconidial isolates were obtained by sub-culturing a single conidium of *V. dahliae* onto Czapek-Dox Agar.

In vitro sensitivity by gradient plating of *Verticillium dahliae* isolates to fluopyram: Fluopyram solutions of 10,000 mg/liter were prepared by dissolving commercial-grade fungicides in a sterile solvent. 50 ml of Czapek-Dox Agar was poured into each dish, to form a layer of agar with a known constant volume, thus when a stock solution is added to the agar results in a gradient from 0 to 1000 mg/liter across the surface. A method using a spiral gradient plater (Figures 1 and 2) was used to determine effective concentration in inhibiting growth by 50% (EC_{50}). Pure cultures of *V. dahliae* were prepared as described above and used in sensitivity assays. Conidial suspensions were prepared by flooding colony Petri dishes with 200 mL distilled water and scraping the conidia free from the surface with a rubber policeman. The conidial suspension (10 mL) was spread across the fungicide gradient plate from edge to center. The point coordinates at which the colonies start and end was recorded and entered into a software program, which calculates the EC_{50} for each isolate.

Results: The mean EC_{50} values were estimated for each of the isolates. A total of 8 isolates that were screened against fluopyram showed no response to the fungicide (Table 1). While there was no response to fluopyram insofar as the sensitivity of each isolate, there was an observable isolate dependent difference in the formation of microsclerotia in-vitro (Figure 1). This is of note because of the impact of both colonization within the potato plant and due to the persistence of microsclerotia in the soil and their role as primary inoculum for Verticillium wilt on potatoes.

Ongoing and future directions: Currently we are comparing the accuracy and precision of the spiral gradient method to traditional dilution agar plating in determining fungicide sensitivity. We will use the same isolates used in the spiral planting assay to test for sensitivity to fluopyram. Additionally, further testing of the ability to produce and the viability of mircosclerotia on fluopyram amended agar may be warranted. Future research should attempt to understand the temporal effect that pyramethanil + fluopyram is having on RLN and whether this interaction is contributing to a decrease in Verticillium wilt symptoms when pyramethanil + fluopyram is applied to potato in-furrow and at emergence.

Table 1. Comparison of mean effective concentration in growth by 50% (EC_{50}) for isolates of *Verticillium dahliae* to fluopyram.

Isolate	Origin	EC_{50} (mg/L)[a]
49.B.2010	WA	105
UM1	ND	105
UM2	ND	105
H5	ND	105
MN3D	ND	105
V1	MI	105
V3	MI	105
V18	MI	105

[a] EC50 values determined for two replications based on mean effective concentration in growth by 50% by spiral gradient dilution method.

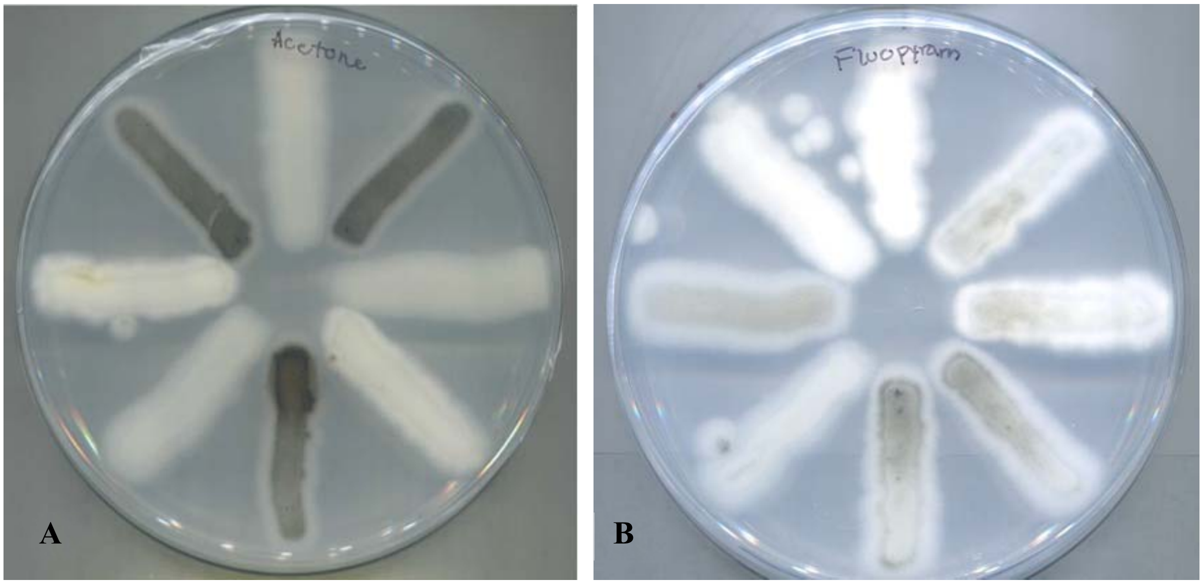

Figure 1. Growth of *Verticillium dahliae* (isolates placed on the same position on the plate) from spiral plate dilution gradient assay on non-fungicide amended plate (A) and fluopyram plate (B).

Potato (*Solanum tuberosum*) 'Snowden'
Potato Common Scab; *Streptomyces* spp.

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In-furrow safety of Omega 500F and foliar treatment programs for control of potato common scab-Clarksville 2017

A field trial was established 9 Jun (latitude 42°52'26.68"N and longitude - 85°15'10.23"W) at the Clarksville Research Center, Clarksville MI to evaluate selected in-furrow and foliar fungicide programs for safety of Omega 500 F and control of potato common scab (Table 1). US#1 'Snowden' tubers were mechanically cut into approximately 2 oz seed pieces 1 Jun and allowed to heal before planting. These trials were conducted using potato cultivar 'Snowden' due to its susceptibility to common scab and its commercial use throughout the state of Michigan and the Midwestern US potato growing region. A randomized complete block design with four replications was used for the experiment, with each plot consisting of four 50-ft-long rows spaced 34 in. apart with tubers 10 in. apart in the row. A 5 ft non-planted alley separated the four-row beds. 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). In-furrow, at-planting applications of fungicide were delivered in 8 pt water/A in a 7 in band using a single XR11003VS nozzle at 30 psi. All experimental foliar treatments were band applied with a hand-held R&D spray boom delivering 10 gal/A (50 p.s.i.) and using one XR8002VR nozzle per row. Weeds were controlled by cultivation 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 Pro Systemic Pro 7 oz/A, 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 on 28 Sep.

Plant stand was rated 24, 28, 33 and 38 days after planting (DAP) and relative rate of emergence was calculated as the Relative Area Under the Emergence Progress Curve [RAUEPC from 0–38 DAP, maximum value = 100]. Vine vigor was assessed on a 1-10 scale 38 DAP. Plots (1 x 50-ft row) were machine-harvested on 27 Oct (140 DAP) and individual treatments were weighed and graded. The number of total, marketable and oversize tubers per plant was calculated. Incidence of common scab was recorded from a sample of 100 tubers/plot and severity of common scab was measured as surface area affected (1=1 lesion to 1%; 2= 1.1-10%; 3=10.1-20%; 4= 20.1-30%; 5= > 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 a percentage. Increasing index values indicated the degree of severity. Severity of common scab (*Streptomyces* spp.) was rated 140 days after planting (DAP). Data was analyzed using ANOVA and differences among treatments were determined using mean separation with Fisher's Protected LSD.

Meteorological Data

Meteorological variables were measured with a Campbell weather station located at the farm from 1 Jun to the end of Sept. Average daily air temperature (ºF) was 67.8, 70.6, 66.6, and 66.6 (Jun, Jul, Aug and Sep respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except Sep with 5 days. Average daily relative humidity (%) over the same period was 65.8, 69.6, 71.1 and 71.6. Average daily soil temperature at 4" depth (ºF) over the same period was 58.1, 69.4, 71.3, 70.2 and 71.6. Average daily soil moisture at 4" depth (% of field capacity) over the same period was 35.2, 36.6, 36.0, and 31.2. Precipitation (in.) over the same period was 5.71, 2.27, 2.98, and 0.0". Plots were irrigated to supplement precipitation to about 0.1 in./A/4 day period overhead sprinkle irrigation.

Results

The 2017 growing season provided environmental extremes of excessive moisture early in the season and moisture stress at other times. However, a prolonged period of unusually dry weather continuing from early Jul to mid-Aug is typically conducive to scab development particularly during tuber initiation. No treatments were significantly different in percent plant emergence, rate of emergence (RAUEPC), vine vigor, incidence and severity of common scab (%), total and marketable yield in hundred- weight per acre, and total and marketable number of tubers per plant. The in-furrow treatment with a low rate of Omega 500F (0.88 pt/A) had significantly lower yield of oversize tubers (CWT) and lower number of B-size and oversize tubers per plant compared to the higher rate (1.77 pt/A). No phytotoxicity was observed from any treatments. The particular soil type (Lapeer sandy loam) in the plots did not provide a scab conducive soil environment, which possibly contributed to low scab incidence and severity than expected. Further experimental field trials on efficacy of scab control should be conducted on more sandy soil.

Table 1. Effects of foliar treatments on percent plant emergence, rate of emergence, vine vigor, incidence and severity of common scab, total and marketable yield in hundred-weight per acre, and total and marketable number of tubers per plant.

Treatment, rate and application time	Plant stand[a] 38 DAP[b] (%)	RAUEPC[c] 0 – 38 DAP	Vigor[d] 38 DAP	Potato Common Scab Severity (%)[e] 140 DAP	Potato Common Scab Incidence 140 DAP	Yield (CWT)[f] Total	Yield (CWT)[f] US #1	Yield (CWT)[f] B Size	Yield (CWT)[f] Oversize	# of tubers/plant[f] Total	# of tubers/plant[f] US #1	# of tubers/plant[f] B Size	# of tubers/plant[f] Oversize
Emesto Silver 0.31 fl oz/CWT seed treatment Quadris Top 6.0 fl oz/A at wk. 4 Bravo WS 1.5 pt/A at wks. 5,7,8,10,12 Revus Top 7.0 fl oz/A at wks. 6,9 Luna Tranquility 11.2 fl oz/A at wks. 11,14,15	91.0	0.54	8.5	20.7	56.3	267.2	178.0	73.7	15.5 ab	5.4	1.8	0.46 ab	0.12 ab
CruiserMaxx 0.31 fl oz/CWT seed treatment Omega 0.88 pt/A in-furrow Quadris Top 8.0 fl oz/A at wk. 4 Bravo WS 1.5 pt/A at wks. 5,7,8,10,12 Revus Top 7.0 fl oz/A at wk. 6,9 Luna Tranquility 11.2 fl oz/A at wks. 11,14,15	96.3	0.55	8.0	18.3	54.5	229.6	142.6	76.9	10.1 b	4.7	1.7	0.51 b	0.07 b
CruiserMaxx 0.31 fl oz/CWT seed treatment Omega 1.77 pt/A in-furrow Quadris Top 8.0 fl oz/A at wk. 4 Bravo WS 1.5 pt/A at wks. 5,7,8,10,12 Revus Top 7.0 fl oz/A at wk. 6,9 Luna Tranquility 11.2 fl oz/A at wks. 11,14,15	94.1	0.56	7.0	16.7	54.3	236.8	155.3	57.8	23.8 a	4.2	1.7	0.43 a	0.16 a

[a] Plant stand expressed as a percentage of the target population of 120 plants/100ft. row from a sample of 1 x 50 ft rows per plot.
[b] DAP = days after planting.
[c] Relative area under the emergence progress curve from planting to 38 days after planting.
[d] Vine vigor rated on a scale of 1-10.
[e] Severity of common scab was measured as surface area affected (1=1 lesion to 1%; 2= 1.1-10%; 3=10.1-20%; 4= 20.1-30%; 5= > 50% surface area).
[f] Means followed by same letter do not significantly differ (*P*=0.10, LSD).

Potato (*Solanum tuberosum)* "Snowden"
Potato Common Scab; *Streptomyces* spp.

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Crop rotations and organic amendments to reduce soil-borne disease severity- Entrican 2017

A field trial was established 8 Jun (43°21'9.24"N and longitude - 85°10'34.61"W) at the Montcalm Research Center, Entrican MI to crop rotations and organic amendments to reduce soil-borne disease severity (Table 1). US#1 'Snowden' tubers were mechanically cut into approximately 2 oz seed pieces 1 Jun and allowed to heal before planting. These trials were conducted using potato cultivar 'Snowden' due to its susceptibility to common scab and its commercial use throughout the state of Michigan and the Midwestern US potato growing region. A randomized complete block design with four replications was used and plots consisted of the following treatments: 1) Potato, Potato (conventional fertilization); 2) Potato, Potato (conventional fertilization + chicken litter); 3) Potato, Potato (conventional fertilization + compost); 4) Potato, Potato (conventional fertilization + compost + chicken litter); 5) Corn, Potato (conventional fertilization); 6) Corn, Potato (conventional fertilization + chicken litter); 7) Corn, Potato (conventional fertilization + compost); and 8) Corn, Potato (conventional fertilization + compost + chicken litter). Each plot consisting of four 50-ft-long rows spaced 34 in. apart with tubers 10 in. apart in the row. A 5 ft non-planted alley separated the four-row beds. 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). In-furrow, at-planting applications of fungicide were delivered in 8 pt water/A in a 7 in band using a single XR11003VS nozzle at 30 psi. Weeds were controlled by cultivation 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 Pro Systemic Pro 7 oz/A, 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 on 21 Sep.

Plant stand was rated 24 days after planting (DAP) and percent emergence was calculated. Plots (1 x 50-ft row) were machine-harvested on 5 Oct (119 DAP) and individual treatments were weighed and graded. The number of total, marketable and oversize tubers per plant was calculated. Incidence of common scab was recorded from a sample of 50 tubers/plot and severity of common scab was measured as surface area affected (1=1 lesion to 1%; 2= 1.1-10%; 3=10.1-20%; 4= 20.1-30%; 5= > 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 a percentage. Increasing index values indicated the degree of severity. Severity of common scab (*Streptomyces* spp.) was rated 119 days after planting (DAP). Data was analyzed using ANOVA and differences among treatments were determined using mean separation with Fisher's Protected LSD.

Meteorological Data

Meteorological variables were measured with a Campbell weather station located at the farm from 1 May to the end of Sept. Average daily air temperature (ºF) was 55.0, 68.5, 69.8, 64.9 and 63.5 (May, Jun, Jul, Aug and Sep respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except Sep with 5 days. Average daily relative humidity (%) over the same period was 68.0, 74.6, 74.0, 75.2 and 73.4. Average daily soil temperature at 4 in. depth (ºF) over the same period was 58.1, 69.4, 71.3, 70.2 and 69.8. Average daily soil moisture at 4 in. depth (% of field capacity) over the same period was 12.4, 14.0, 9.4, 6.7 and 7.3. Precipitation (in.) over the same period was 1.98, 6.37, 0.92, 1.36 and 0.7". Plots were irrigated to supplement precipitation to about 0.1 in./A/4 d period with overhead sprinkle irrigation.

Results

The 2017 growing season provided environmental extremes of excessive moisture early in the season and moisture stress at other times. However, a prolonged period of unusually dry weather continuing from early Jul to mid-Aug is typically conducive to scab development particularly during tuber initiation. No treatments were significantly different in total and US#1 yield in hundred-weight per acre (CWT) and severity of common scab

(Table 1). The treatments with significantly lower CWT yield of B-size tubers were potato, potato (conventional fertilization + compost) and potato, potato (conventional fertilization + compost + chicken litter) but were not significantly different from potato, potato (conventional fertilization + chicken litter) (Table 1). The treatment with significantly lower scab incidence was potato, potato (conventional fertilization) but was not significantly different from potato, potato (conventional fertilization + compost) (Table 1). The treatment with significantly higher emergence (%) was potato, potato (conventional fertilization + compost) compared to one treatment potato, potato (conventional fertilization + compost + chicken litter) (Table 1).

Table 1. Effects long-term rotational potato crop management treatments on percent plant emergence, incidence and severity of common scab, total and marketable yield in hundred-weight per acre.

	119 (DAP)[a,b,c]					
	Yield (CWT)[d]					
Treatment Rate	**Total**	**US #1**	**B Size**	**Scab Incidence**	**Scab Severity[e]**	**% Emergence**
Potatoes, PPPP Inorganic MAP 11-52-0, 120 lb ai/A K2O 0-0-62, 150 lb ai/A AS 21-0-0-24, 66 lb ai/A Urea 46-0-0, 134 lb ai/A	146.8	68.1	78.7 a	79.0 b	63.8	95.4ab
Potatoes, PPPP Organic Herbrucks, 2 ton/A AS 21-0-0-24, 40 lb ai/A Urea 46-0-0, 80 lb ai/A	126.8	57.4	69.4 ab	100 a	75.5	95.4ab
Potatoes, PPPP Inorganic MAP 11-52-0, 120 lb ai/A K2O 0-0-62, 150 lb ai/A AS 21-0-0-24, 66 lb ai/A Urea 46-0-0, 134 lb ai/A Compost, 1 ton/A	124.2	61.5	62.7a b	93.4 ab	62.6	95.8a
Potatoes, PPPP Organic Herbrucks, 2 ton/A AS 1-0-0-24, 40 lb ai/A Urea 46-0-0, 80 lb ai/A Compost, 1 ton/A	113.8	55.0	58.8 b	99.7 a	76.7	90.8b

[a] Rotation treatments included: 1) Potato, Potato (conventional fertilization); 2) Potato, Potato (conventional fertilization + chicken litter); 3) Potato, Potato (conventional fertilization + compost); 4) Potato, Potato (conventional fertilization + compost + chicken litter).
[b] DAP=days after planting
[c] Means followed by same letter do not significantly differ (*P*=0.10, LSD).
[d] Yield in hundred-weight per acre
[e] Severity of common scab was measured as surface area affected (1=1 lesion to 1%; 2= 1.1-10%; 3=10.1-20%; 4= 20.1-30%; 5= > 50% surface area).

Progress report for 2017 Research Grant from
Michigan Potato Industry Commission

Project Title: Building climate variability into models that forecast pest pressure on potato and developing strategies for managing potato pests in the face of extreme weather

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Summary of Problem

Models that forecast insect pest pressure are key tools that support decision making in pest management. These models turn biological knowledge and weather data into predictions that allow growers to anticipate pest pressure and stop pest outbreaks before they begin[1]. For example, in Michigan one of the key platforms for forecasting models is Michigan State University's EnviroWeather (enviroweather.msu.edu), which has freely available models that forecast pest pressure on field, fruit, nursery, and vegetable crops, including potato. These models are currently not built to account for extreme weather events like heat waves, which are becoming more common and more intense in Michigan and around the world[2,3]. If pest forecast models are not updated to include the biological effects of extreme events, then they will become inaccurate, making pest management more difficult and costly.

A growing number of studies have examined the effects of increasing temperatures on crops and insect pests, but such studies have only examined small increases in temperature averages[4]. Such studies have overlooked the potentially more important effects of heat waves on crops and insect pests[5]. We conducted a series of experiments using potato and Colorado potato beetle (*Leptinotarsa decemlineata*; CPB) where we subjected potato and/or CPB to heat waves at different times during the potato life cycle and tracked potato growth, potato yield, CPB defoliation, CPB survival, and CPB growth.

Methods

The colony of CPB used for the experiments are descendants of wild individuals collected from Michigan potato fields. The colony was raised on *Solanum tuberosum* (cv. Atlantic) and eggs were collected and hatched as needed. We conducted a series of experiments in environmental growth chambers from July 2017 through January 2018. For each experiment, we planted certified seed potatoes (cv. Atlantic) into 450 ml round green pots and started them in two BioChambers FxC19 environmental chambers set to mimic average early summer conditions in Southern Michigan: 16 hours of daylight, daytime temperature of 26 C, 8 hours of dark, nighttime temperature of 14 C, with a two-hour ramp between temperature changes. Humidity was set at 40% and fan speed was at 75% for both chambers. Light levels were measured and balanced at 170 µmol m^{-2} s^{-1} using an apogee quantum flux light meter. We simulated heat wave conditions by moving plants to a second, otherwise identical chamber set to a maximum daily temperature of 40 C and a nighttime temperature of 26 C for four days. Other conditions were kept constant. After heat waves, plants were moved back to the original chamber.

The factorial heat wave-CPB experiment—In the first experiment we report below, we examined the separate and combined effects of a heat wave event and CPB defoliation on potato growth and yield, and simultaneously examined the effects of a heat wave event on CPB survival and growth. In this experiment, we grew 134 potato plants until they were 46 days old and added one first instar CPB larva each to half of all plants. Then on day 49, half of the plants with a CPB larva and half of the insect-free plants were moved to heat wave conditions (described above). We ran the experiment until surviving CPB finished feeding and dug down into the soil for pupation, which occurred as potato plants were flowering. At the end of the experiment, we measured plant height, plant developmental stage, potato yield, CPB developmental stage, and CPB mass. We also collected leaf tissue to analyze for protease inhibitor activity, a key defense against insect pests and saved CPB bodies to analyze for lipid content, a key measure of beetle health that is related to beetle fecundity. We are currently in the process of completing the lab work for these analyses. We analyzed all normally distributed response variables using linear mixed effects models and survival response variables using a binomial generalized linear mixed effects model. All models with CPB response variables included a random effect to account for correlations among larvae from the same clutch.

Heat wave timing experiment—In the second experiment we report below, we examined how the effects of heat waves on potato production and interactions between potato growth and CPB defoliation depend on the seasonal timing of a heat wave. We grew 153 potato plants in growth chambers as described above and randomly assigned 51 to a control temperature treatment, 51 to an early heat wave treatment, and 51 to a late heat wave treatment. For the early heat wave treatment, we moved plants to a chamber with heat wave conditions for four days starting when they were 39 days old. For the late heat wave treatment, we did the same but when plants were 53 days old. Then when all plants were 60 days old and after the end of the heat wave treatments, we randomly assigned half of the plants in each control or heat wave treatment group to receive a first instar CPB larva. At the end of the experiment, we measured plant height, plant developmental stage, potato yield, CPB developmental stage, and CPB mass; and we collected leaf tissue and CPB tissue for analysis of protease inhibitor activity and lipid content. Again, the analyses for those last two measurements are still in progress (to be completed in spring 2018). We analyzed all normally distributed response variables using linear mixed effects models and survival response variables using a binomial generalized linear mixed effects model. All models with CPB response variables included a random effect to account for correlations among larvae from the same clutch.

Field experiments—A key component of our work on this project was developing experimental methods for subjecting potato plants to realistic heat wave conditions in the field. Previous studies on thermal plant biology have used infrared heaters to examine the responses of plants to small, long lasting temperature increases. No studies, to our knowledge, have examined the responses of plants, growing normally in the field, to experimental heat wave conditions of extremely high temperatures. We spent a major proportion of the summer working with an electrician building infrared heaters capable of heating small plots of plants to 40 C for several days. To ensure that we were producing conditions that mimicked realistic Michigan heat waves, we used data loggers to track temperature and humidity. Below we present data showing that we are able to create realistic heat wave conditions. We plan to use these methods on potatoes in the field in summer 2018.

Results and Discussion

Factorial heat wave-CPB experiment—We found that potato plants subject to experimental heat wave events and CPB damage had 18 % reductions in potato tuber yield on average (Fig. 1). These effects, however, were not statistically significant ($F = 2.1$, $df = 2$, $P = 0.13$), and we are currently repeating this experiment to see if the trend is real. If this reduction in yield holds, it would be especially surprising because it occurred even though the heat events cut CPB survival in half ($\chi^2 = 9.0$, $df = 1$, $P = 0.003$) (Fig. 2). These results suggest that heat wave events may reduce CPB densities in the field by killing larvae, but that heat waves may also reduce potato yield directly and indirectly by increasing susceptibility to beetles that survive the heat wave events. This suggests that the net effect of heat waves on potato production and interactions between potato plants and insect pests may depend on the details of how and when heat waves occur, which is the subject of our second experiment.

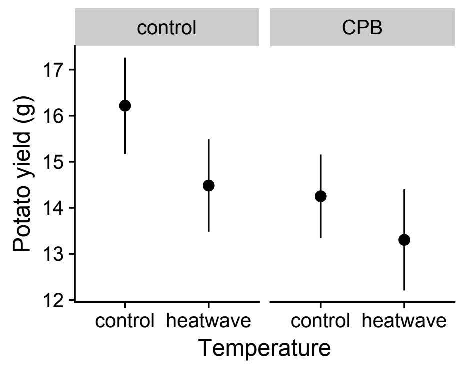

Fig. 1. Potato yield from plants with or without Colorado potato beetle damage and with or without a 4-day heatwave. Yield is reduced by heatwaves, CPB damage, and both. Points and lines show means and ±1 SE.

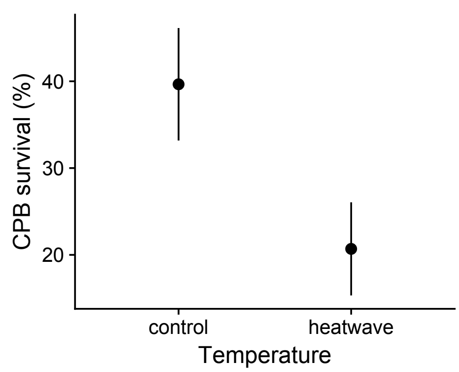

Fig. 2. Beetles that experience a 4-day heatwave have reduced survival. Points and lines show means and ±1 SE.

Heat wave timing experiment—In this experiment we subjected potato plants to no heat wave, an early heat wave (day 39), or a late heat wave (day 53), and then on day 60, after all heat wave treatments were over and while plants were beginning to flower, we randomly assigned half of the plants in each temperature treatment to receive one first instar larva. We found that heat waves and CPB defoliation had important interactive effects on potato yield ($F = 7.6$, $df = 5$, $P < 0.0001$) (Fig. 3). In the absence of CPB, heat waves of either timing led to 22.0% reductions in potato yield. Surprisingly, the addition of CPB led to different opposite effects on control plants and heat wave plants. CPB damage actually increased potato yield 26.3%, which was in contrast to the negative effect we found of CPB damage on potato yield in the factorial heat wave-CPB experiment (above). We hypothesize that this counterintuitive result emerged because we only added CPB to plants at the end of the potato life cycle when potatoes had already begun tuber growth. Foliar damage at this time may have simply further encouraged potatoes to store energy belowground in tubers. In the factorial heat wave-CPB experiment (above), we added CPB to plants before tuber production and CPB damage led to lower yield as expected. In this experiment, however, the positive effect of late CPB damage on yield was offset by large reductions in yield when plants also experienced heat waves: 44.6% yield reductions for plants that experienced late CPB damage and an early heat wave and 64.4% yield reductions for plants that experienced late CPB damage and a late heat wave. These results indicate that late season CPB damage, during tuber formation, actually benefits potato yield, whereas heat wave events, regardless of their timing, cause small reductions in yield in the absence of CPB damage. When plants experience heat waves and late season CPB damage, however, yield is dramatically lower, especially when heat waves also come near the end of the growth season. The key implication is that heat wave events can change the effect of a small amount of CPB damage at the end of the season from having a slight positive effect on yield to having a dramatic negative effect on yield. This finding suggests that potato plants have a difficult time coping with the dual stressors of heat waves and late-season CPB damage.

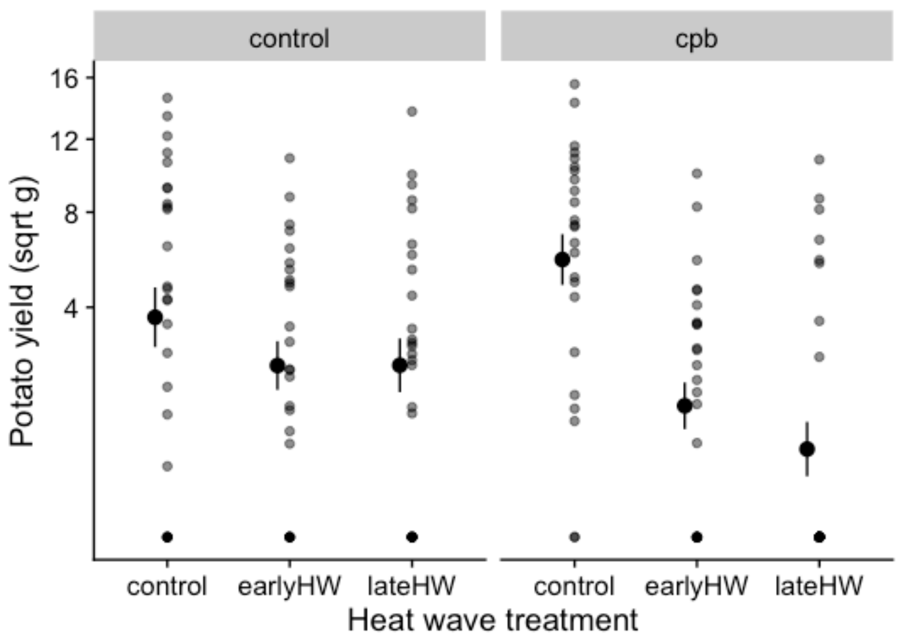

Fig. 3. Potato yield (sqrt g) from plants that experienced control temperature conditions, an early heat wave (HW), or a late heat wave. After the late heat wave, half of the plants in each heat wave treatment received one first instar CPB larva. Small grey points show results for individual plants. Large black points and lines show group means and ±1 SE. The interaction between heat wave treatments and CPB damage is significant ($F = 7.6$, $df = 5$, $P < 0.0001$).

Field experiments—We found that by adjusting the parameters of our infrared heaters (e.g., wattage, distance between heater and plot) we were able to heat plots in the field in July-August approximately 15-20 °F above ambient conditions: daytime temperatures from approximately the low 80s °F to around 100 °F and nighttime temperatures from approximately 50-60 °F to around 70-75 °F. We ran tests of our heaters repeatedly at different times during the summer in different weather conditions and found similar heating results (one example is shown in Fig. 4). These temperatures are representative of a rare heat wave in Southern Michigan over the last century, but such events are predicted to become more common. Thus, these trial runs indicate that our heaters are achieving the type of heating that is needed for experiments on the consequences of heat waves. A key next step in this project is subjecting potato plants to heat wave treatments in the field at the scale of a large field experiment. Having the ability to create heat waves in the field will allow us to see if the results of our growth chamber studies hold up under more natural field conditions. Moreover, conducting heat treatments in the field, as opposed to growth chambers, will let us work with much larger plants and larger populations of insect pests and ask questions on larger and more agriculturally relevant scales.

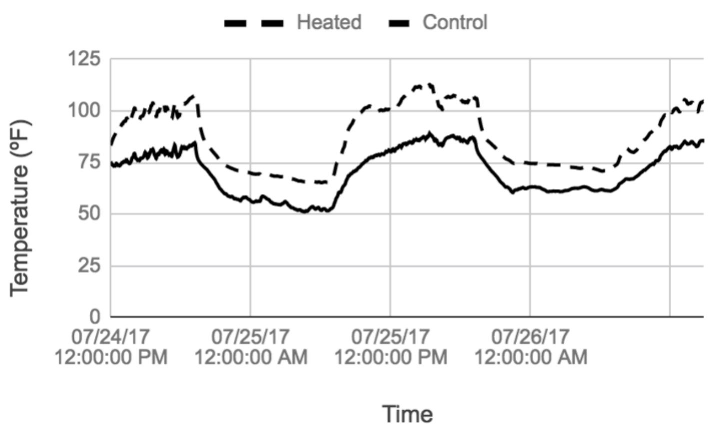

Fig. 4. Temperature in a plot subjected to a two-day simulated heat wave in the field ("Heated") and in an unheated ("Control") plot nearby but outside the range of the heaters. We ran this test repeatedly at different dates under different weather conditions and found similar results.

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Report on Michigan Potato Industry Commission Proposal 2017

Remote sensing to quantify spatial variability of crop nitrogen (N) status and optimize N fertilizer in potato fields

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Objectives
The main objective is to capture N status of the potato crop during the season and apply optimal N fertilizer catered to the spatial and temporal variability measured from historical yield monitor information. Adequate N supplied to the crop can be matched with demand in order to increase nitrogen use efficiency (NUE) that enhances sustainability, leading to great profitability to the grower.

Specific research objectives in field experiments

- *Monitor in-season spatial variation of potato growth and N status using UAVs (unmanned aerial vehicles), and airborne thermal imagery;*
- *Examine relationships between spectral reflectance and crop yield at the field scale.*

Field Experiments
Our collaboration with Main Farms, Inc. in Trufant, Michigan had two fields for study during the growing season of 2017. The two fields for study were: MV2 and S2.

Table 1

Field	Cropping History	Field Size (acres)
MV2	Corn-Soybean-Wheat-Potato-Peas	140.7
S2	Corn-Soybean-Wheat-Potato-Peas	115.4

Objective 1

Methodology

In order to monitor spatial variation of potato growth, we first needed to create a yield stability map from the field's cropping history using yield monitor data. Corn yield maps were collected from MV2 for three years: 2011, 2014, and 2015 (Figure 1). For S2, 5 years of yield maps were collected: 2010, 2011, 2012, 2014, and 2015 (Figure 2). Additional years of data, including more than one crop, provide a greater understanding of the inherent spatial variability in the field.

Our robust analysis of yield stability has been standardized to work across many different crop yield distributions.

Yield stability zones created by historical analysis of yield monitor data led a greater understanding of differentiating zones throughout the grower's field. Use of these zones as experimental units provides the ability to make statistical conclusions in our analysis of various measurements. For in-season monitoring of N, we used UAV (unmanned aerial vehicle) and airborne imagery to detect changes in the field throughout the growing season. Five vegetation indices were created from UAV imagery: normalized difference vegetation index (NDVI) (Figure 3), normalized difference red edge (NDRE) (Figure 4), canopy chlorophyll cover index (CCCI) (Figure 5), green normalized difference index (GNDVI) (Figure 6) and weighted difference vegetation index (WDVI) (Figure 7). Multiple WDVI images were analyzed to calculate ground cover (GC) and their rate of change over time (Figure 8).

Results

Remote sensing images are directly correlated with yield stability zones in the early growing season (June 16). Further along in the growing season, 2.5 weeks later, the relationship balanced due to additional N uniformly applied over the field (Figure 9). The WDVI shows that there is potential to decrease N application in the high and stable yield stability zone because it was not limited by N in the field.

Thermal imagery was captured 7 times during the growing season. Multiple images were taken when the center pivot irrigator was actively running in the field, which distorted the thermal reflectance. However, enough accurate images were collected to create a thermal stability map (Figure 10). Variability in thermal temperatures are related to soil depth and the amount of water in the soil profile. For irrigated fields, the soil water content does not cause problems found in non-irrigated fields, because water can be applied with greater frequency. In Figure 10, hot and stable areas appear around the edge of the field where the irrigator is unable to reach and at parts of the field where topography allows for increased evaporation from the plant, such as hilltops.

Conclusions

UAV images were able to determine crop N supply at early growth stages before the majority of N was applied after hilling. Our yield stability zones showed a response to the WDVI values at the timing of the first image. Each image collected, via UAV or airborne, presents a snapshot of the spatial variability displayed by the field at that particular stage of plant growth. The GC map created from UAV imagery collected at the early part of the growing season shows which parts of the field had the most growth in above-ground biomass with a very high resolution. The thermal stability map confirms areas of hot and cold temperatures and how those areas of the field may contain shallower soils influenced by sandier textures. The soil map provided by SSURGO (nrcs.usda.gov) verifies these areas as a slightly different classification of loamy sand with 0-2% slopes then other parts of the field. These areas respond differently to management, i.e. application of N, and irrigation. Analysis of all the images together to form a single index, or growth change map, provide a more detailed investigation of the variability existing in the field.

Objective 2

Methodology

Both fields were irrigated during the growing season, and they incurred an extreme rainfall event the week of June 18 where over 3 inches of rain fell in a 24-hr period. Large amounts of N were most likely flushed out of the system following the N application at hilling on June 15. During this application, a single strip of reduced N (52 lb/ac) was applied the length of the field. Hand samples were dug September 12 & 14 before machine harvest took place.

Results

Analysis of the digs was used to create a yield map that simulated similar data created from combine yield monitors for most grain crops, like corn and wheat (Figure 11). Further analysis for N uptake and nitrogen use efficiency (NUE) (Figures 12 & 13) showed similar patterns found in the yield map. In Figure 13, the reduced N strip shows the greatest NUE because the amount applied was reduced by 50% during the hilling application. When NUE was separated by yield stability zone, the trend remained with higher NUE occurring in the tactical N management strip (Figure 14).

Potato yields from the hand digs showed no significant differences across stability zones. Unstable zones had the lowest yields, and the reduced N treatment (tactical zone) showed a slight increase in yield, further confirming that the reduced N did not lead to a reduction in potato yields (Figure 15). The yield stability map created after adding the 2017 potato yields (Figure 16) shows a more smoothed and normalized map where the majority of the field (116.5 acres) has fallen into the medium and stable stability zone.

Conclusions

Typical grain crops, i.e. corn, soybean, and wheat, are monitored with great precision utilizing yield monitor technology. Potatoes are a very high value crop, but understanding their spatial and temporal variability is difficult without the conventional approach used in grain crops. Hand digs provide the opportunity to see a more accurate representation of the field when the points are spread across multiple stability zones and varied spatially throughout the field. Most conventional methods for hand digs follows a grid sampling technique, similar to field-scale soil sampling work. This method creates concern for missing differentiation in the field where the images and historical yield monitor data show important areas of spatial variability. Our method utilized these areas to collect potato samples for yield efficiently, and this was confirmed by historical trends found in previous yield maps.

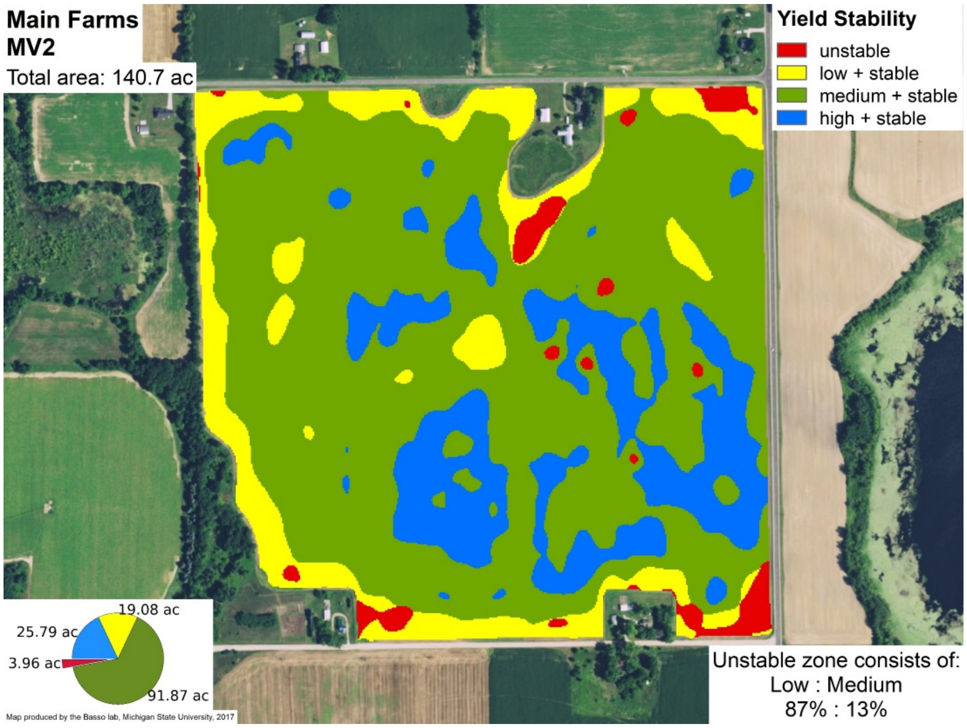

Figure 1. Yield stability map of MV2 located in Trufant, MI.

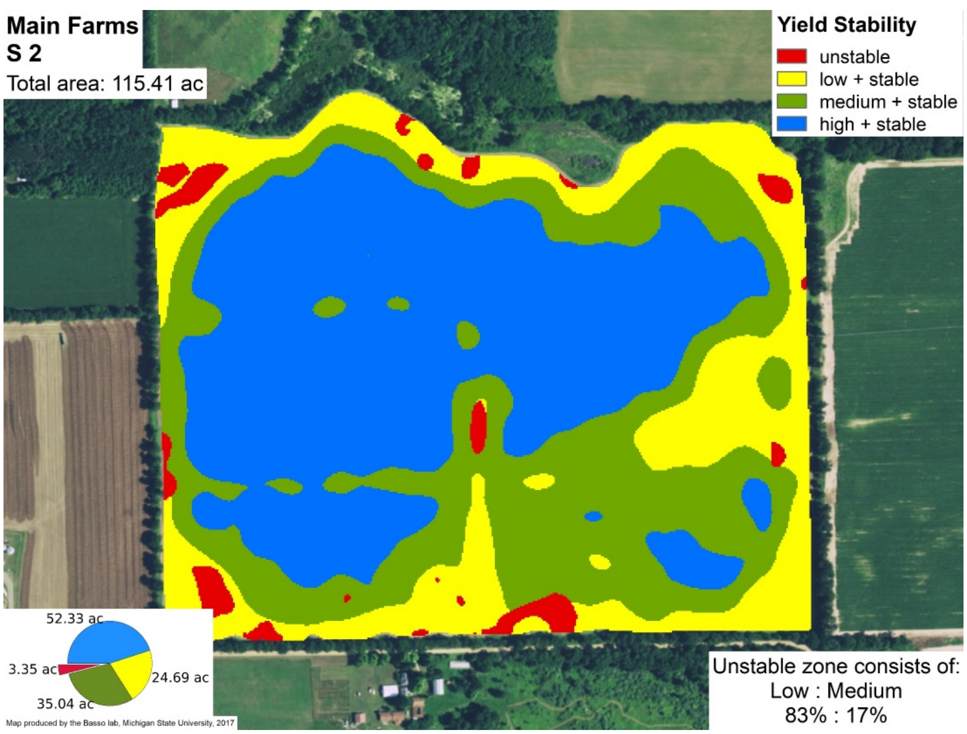

Figure 2. Yield stability map of S2 located in Trufant, MI.

Figure 3. UAV image of NDVI collected at MV2 on June 16, 2017.

Figure 4. UAV image of NDRE collected at MV2 on June 16, 2017.

Figure 5. Canopy chlorophyll content index created from NDVI & NDRE images at MV2 on June 16, 2017.

Figure 6. Green normalized difference vegetation index at MV2 on June 16, 2017.

Figure 7. Weighted difference vegetation index created from using reflectance of bare soil images and crop cover taken on June 16, 2017 at MV2.

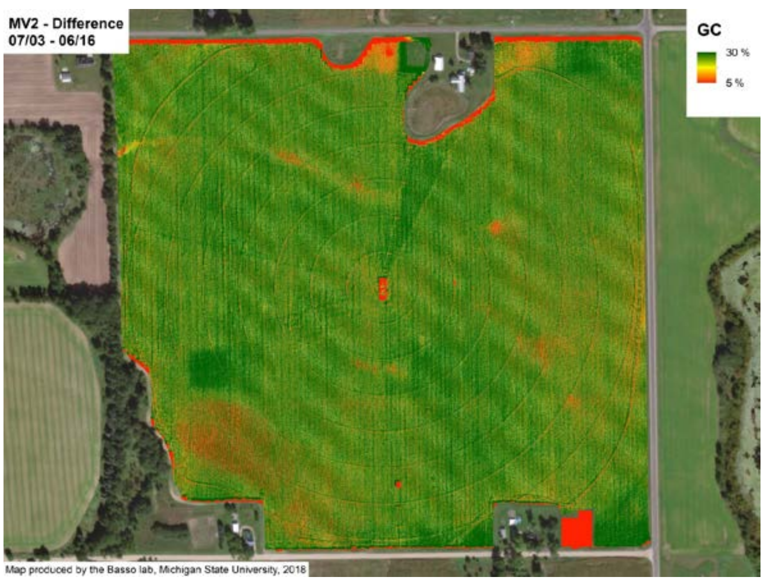

Figure 8. Ground cover accumulated from the time between the two images, June 16 and July 3, 2017 at MV2.

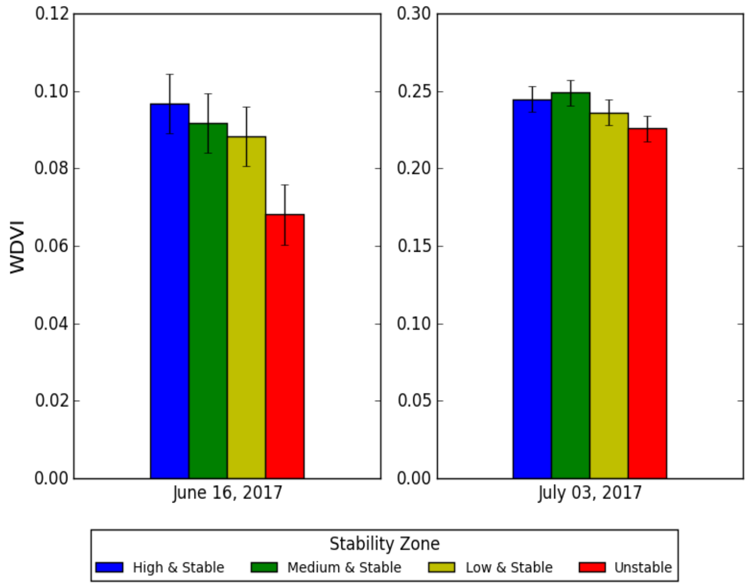

Figure 9. WDVI values for each stability zone taken at each flight at MV2.

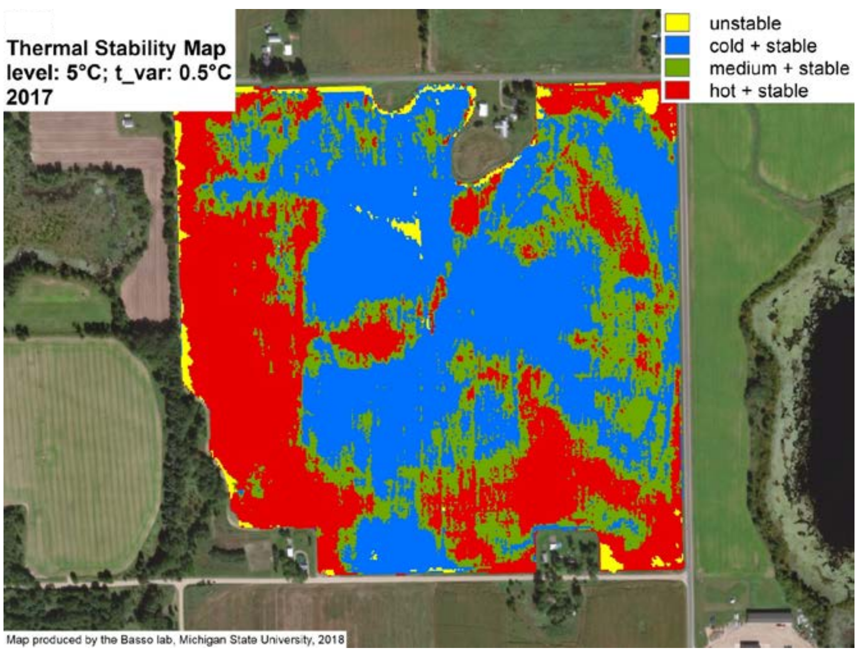

Figure 10. Thermal stability map made from irrigator free images over the course of the growing season at MV2.

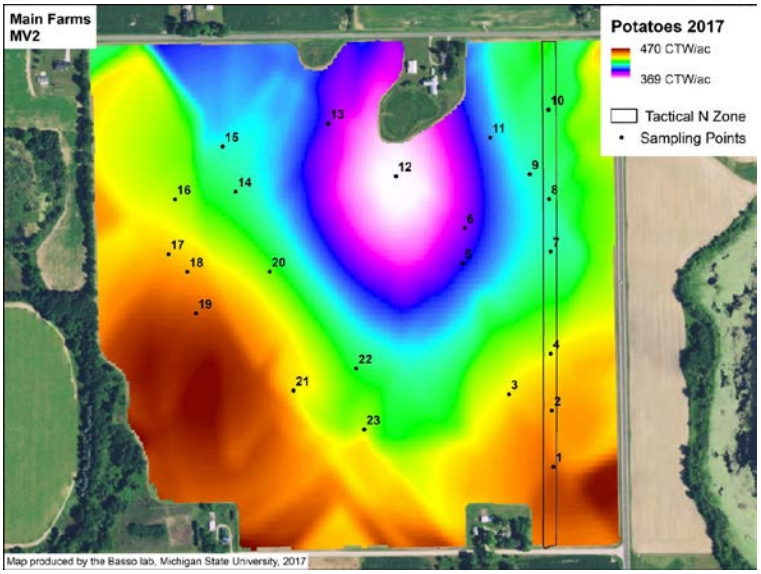

Figure 11. Potato yield map created from interpolation of yields from hand digs at MV2.

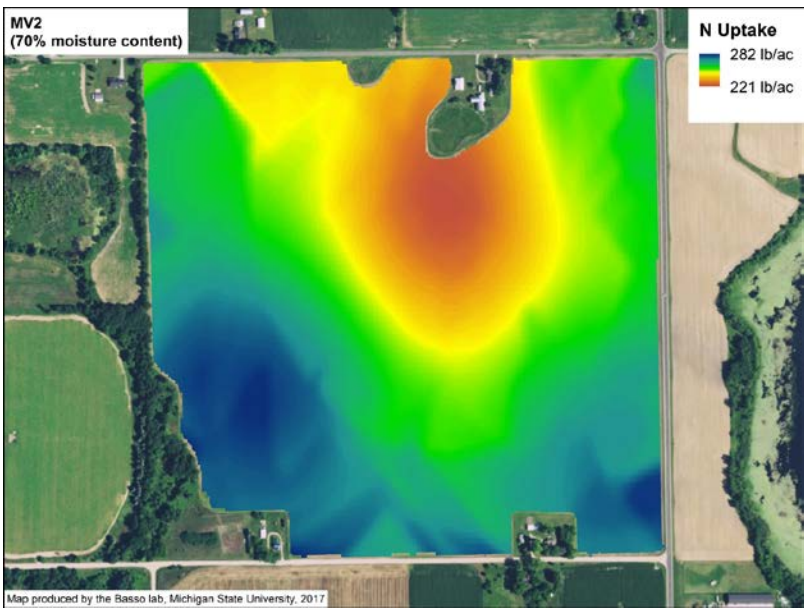

Figure 12. Nitrogen uptake assuming 2% N found in tubers at MV2.

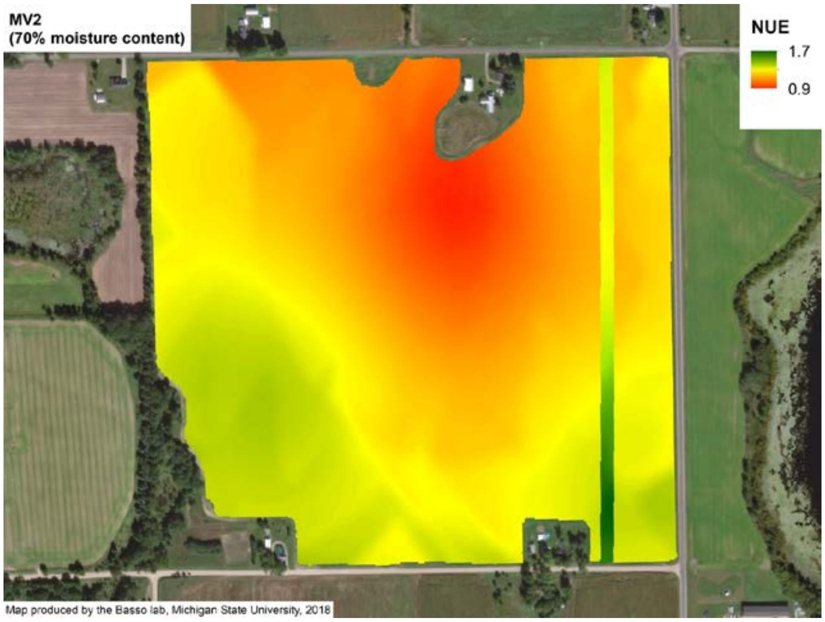

Figure 13. Nitrogen use efficiency from N uptake / N applied at MV2.

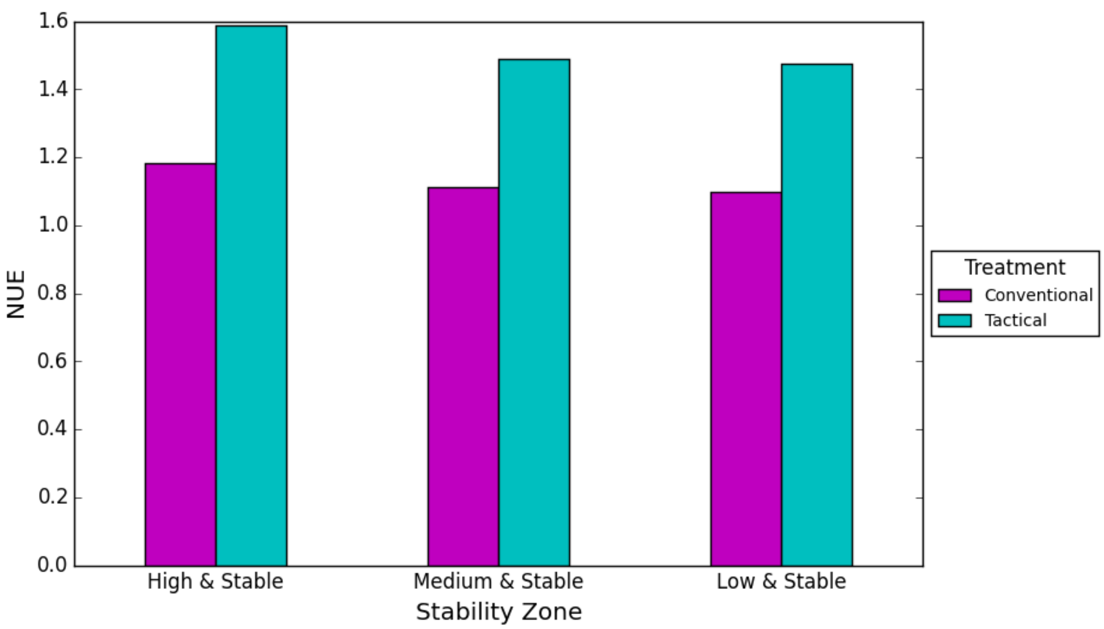

Figure 14. Nitrogen use efficiency in each stability zone compared to conventional management points taken adjacent in the field at MV2.

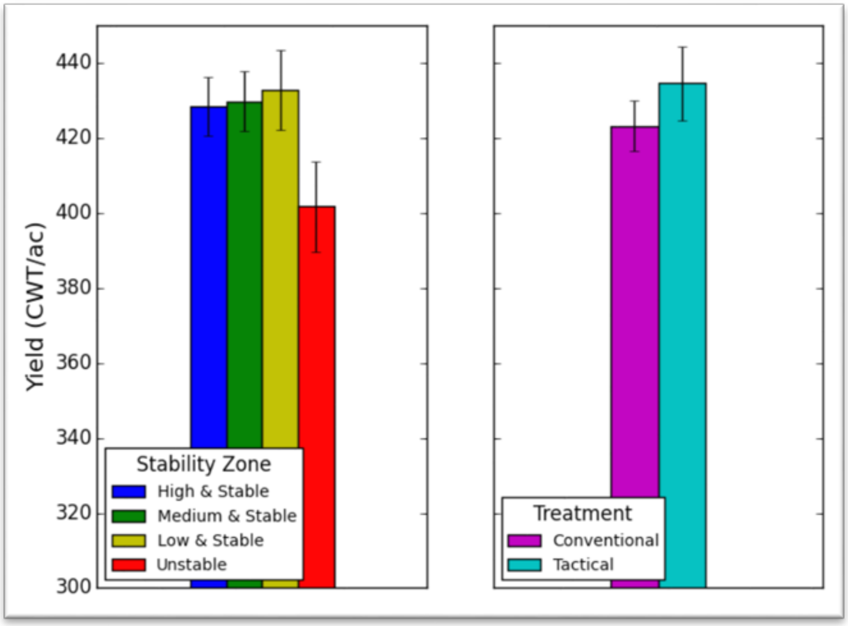

Figure 15. Potato yields separated by stability zone and N treatment for MV2.

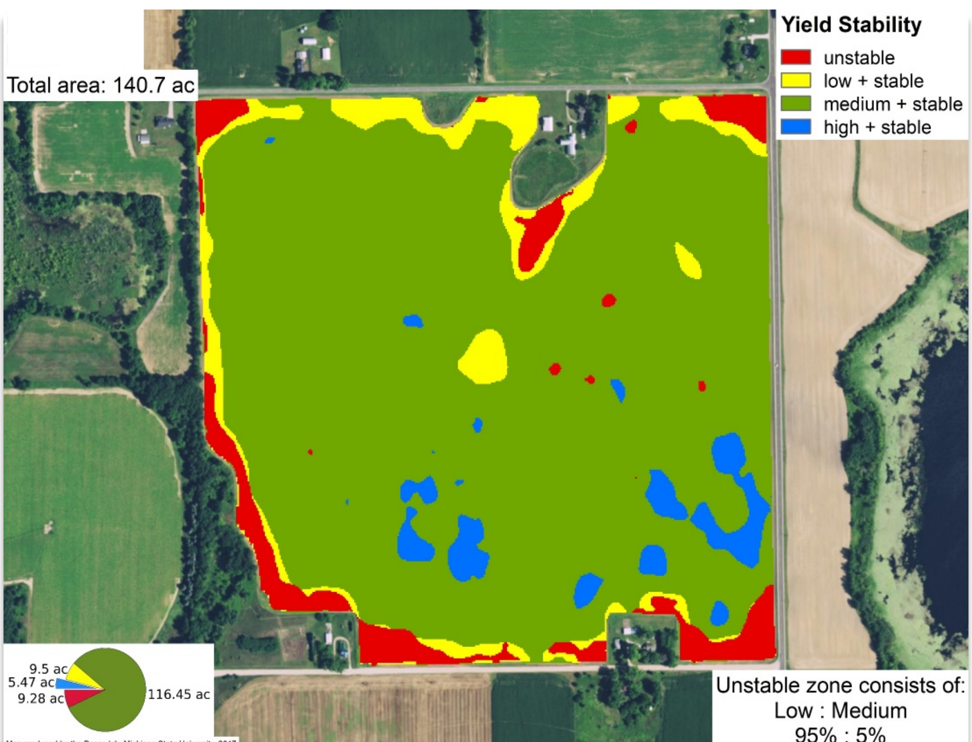

Figure 16. Yield stability map recalculated using information from 2017 potato yields in MV2.

Appendix of additional figures not cited in report.

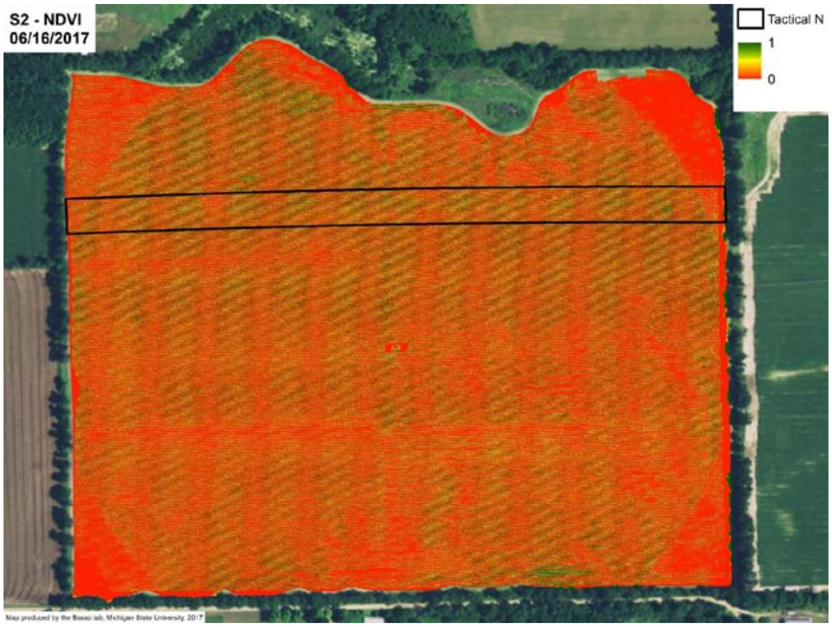

Figure 17. NDVI map created from the UAV on June 16, 2017 at S2.

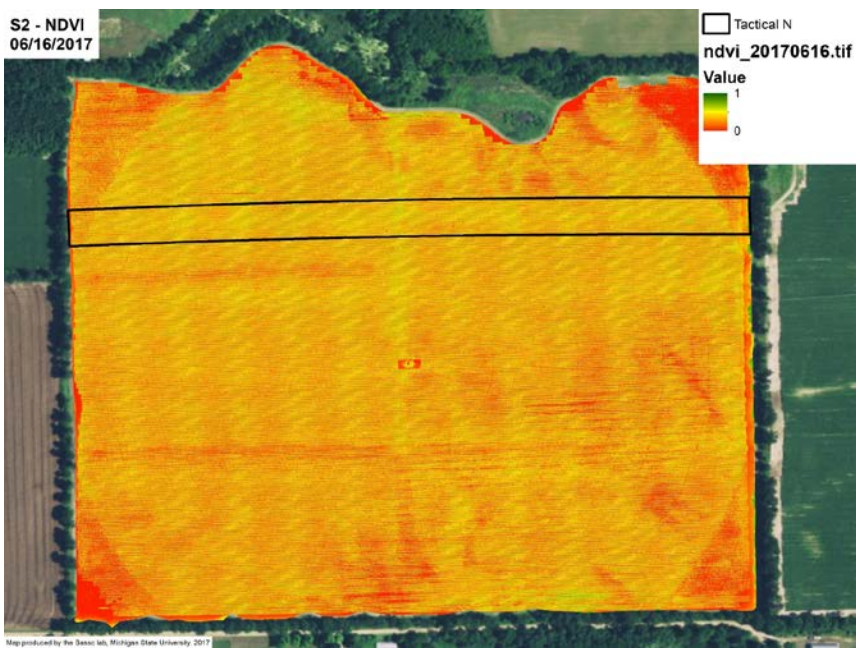

Figure 18. NDRE map created from UAV on June 6, 2017 at S2.

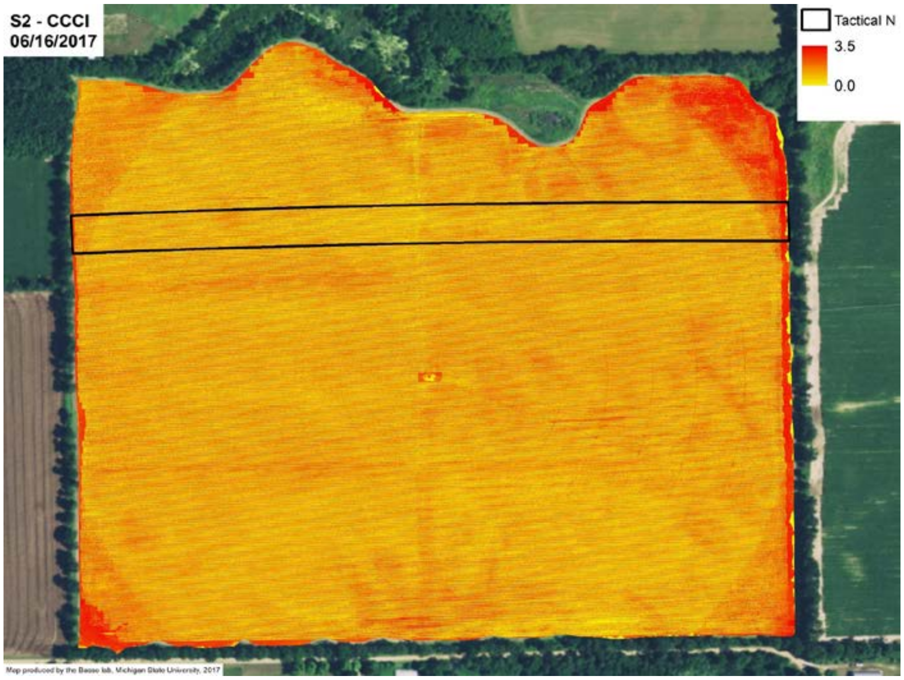

Figure 19. Canopy chlorophyll cover index on June 6, 2017 at S2.

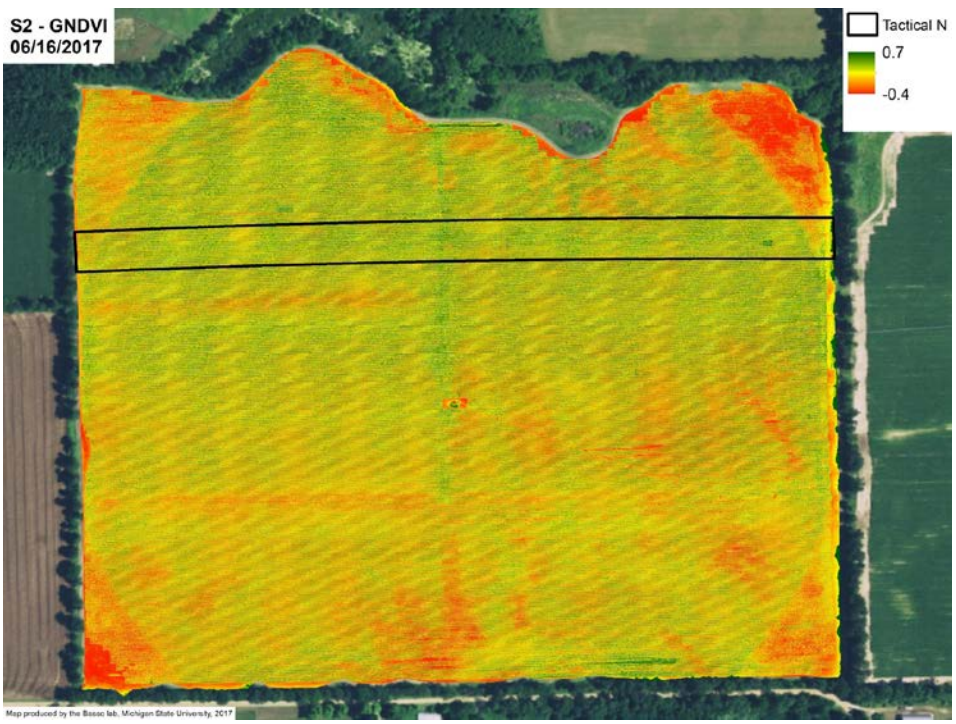

Figure 20. GNDVI map made on June 6, 2017 at S2.

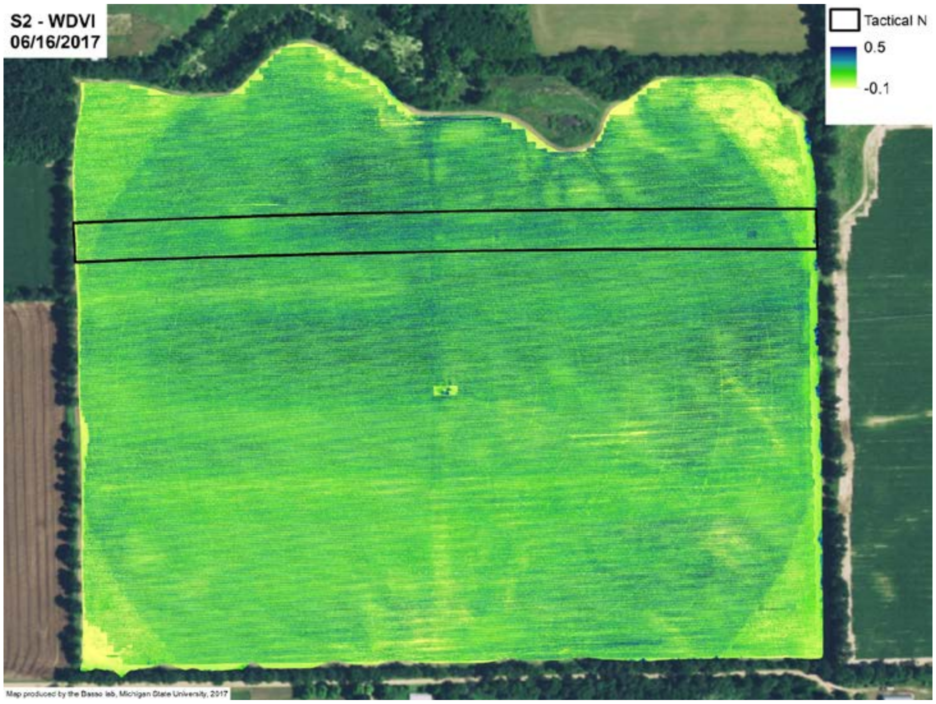

Figure 21. WDVI index made on June 6, 2016 at S2.

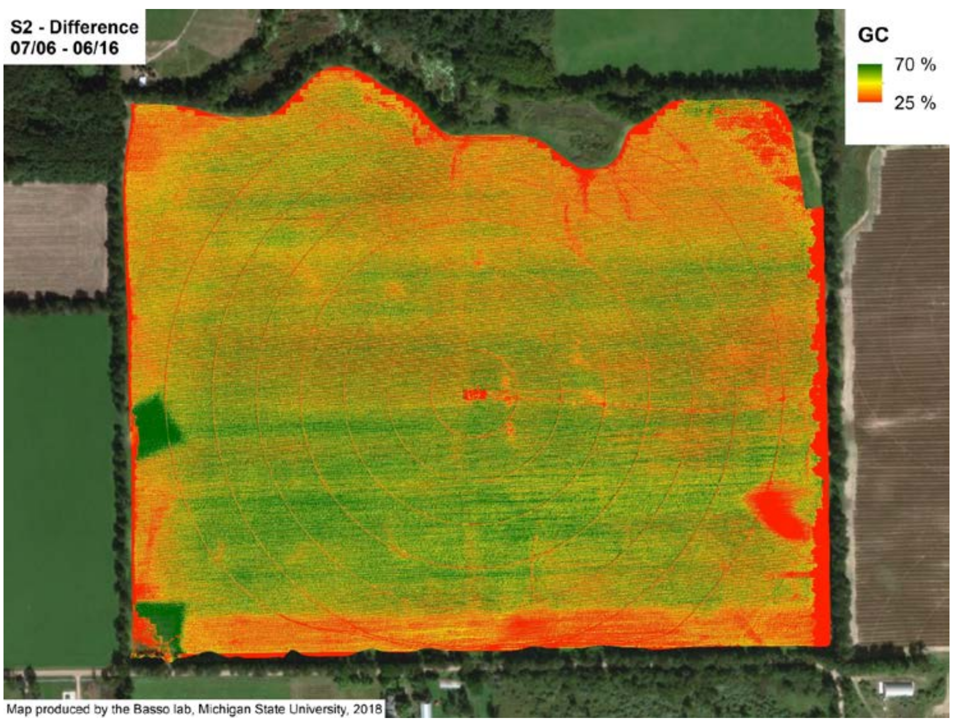

Figure 22. Ground cover difference from June 6 - July 6 at S2.

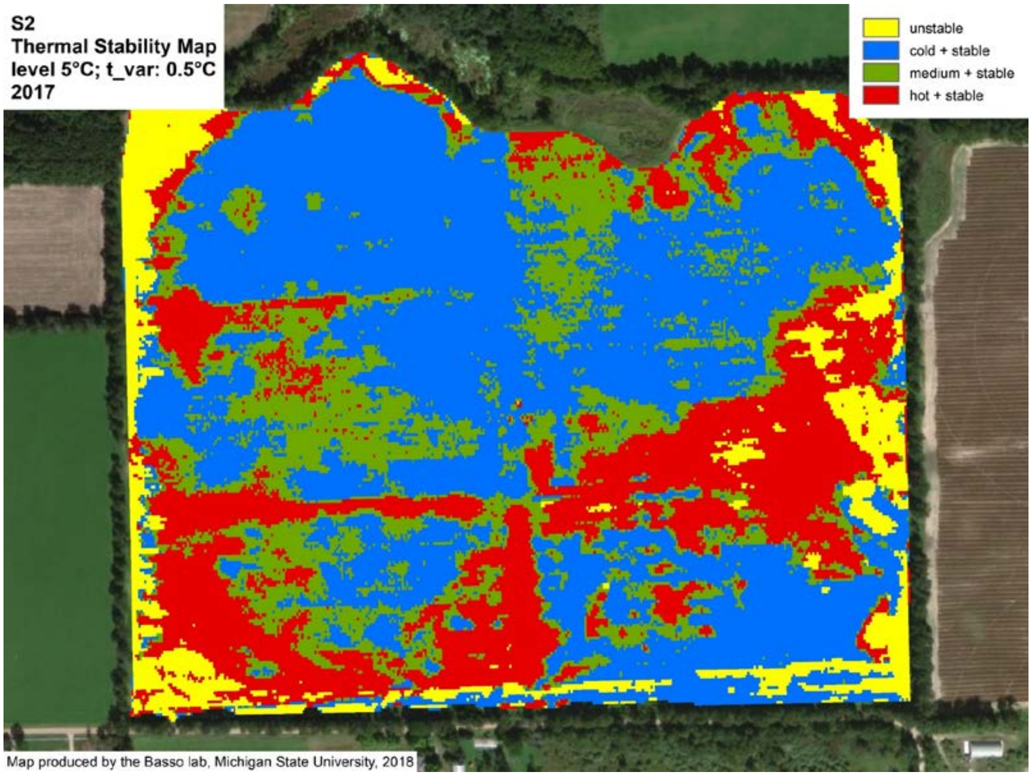

Figure 23. Thermal stability map at S2.

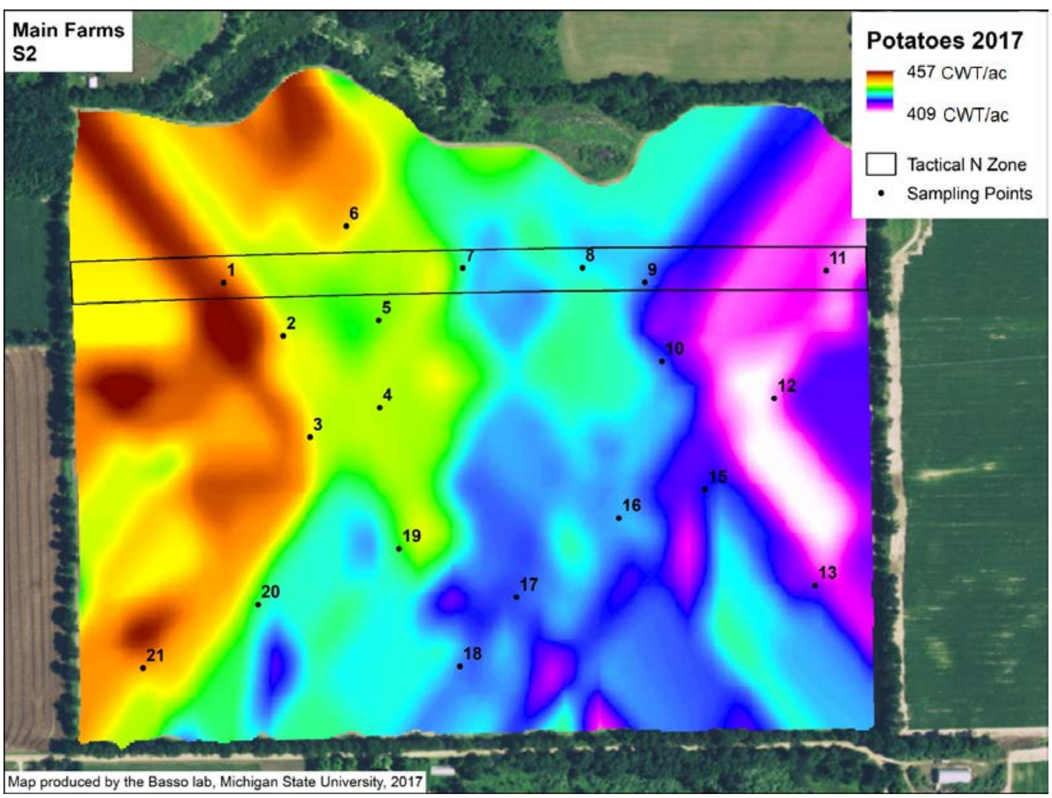

Figure 24. Yield map made from hand digs on September 14, 2017 at S2.

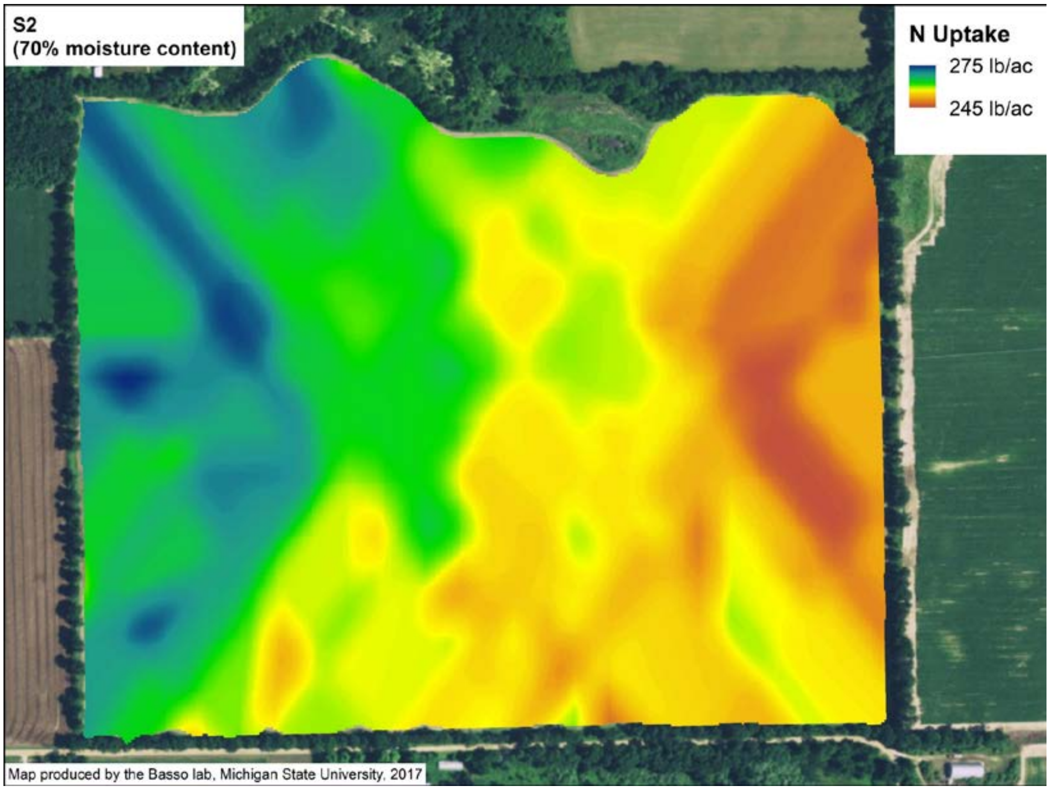

Figure 25. N uptake map using N applied and tuber yield at S2.

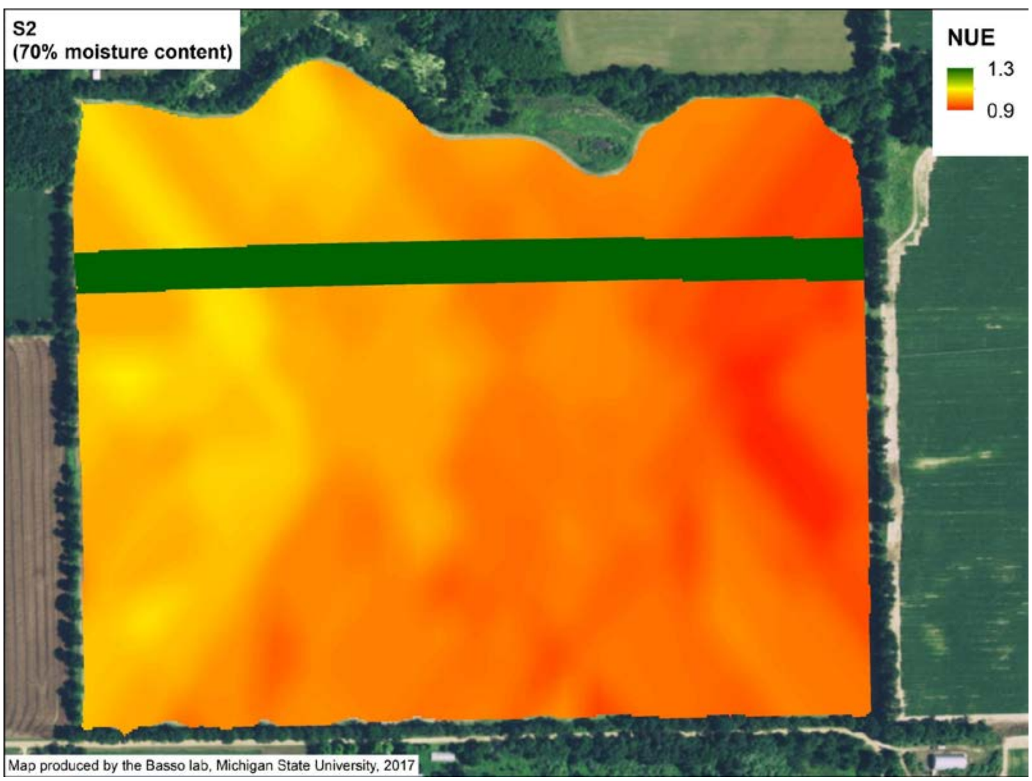

Figure 26. Nitrogen use efficiency map at S2.

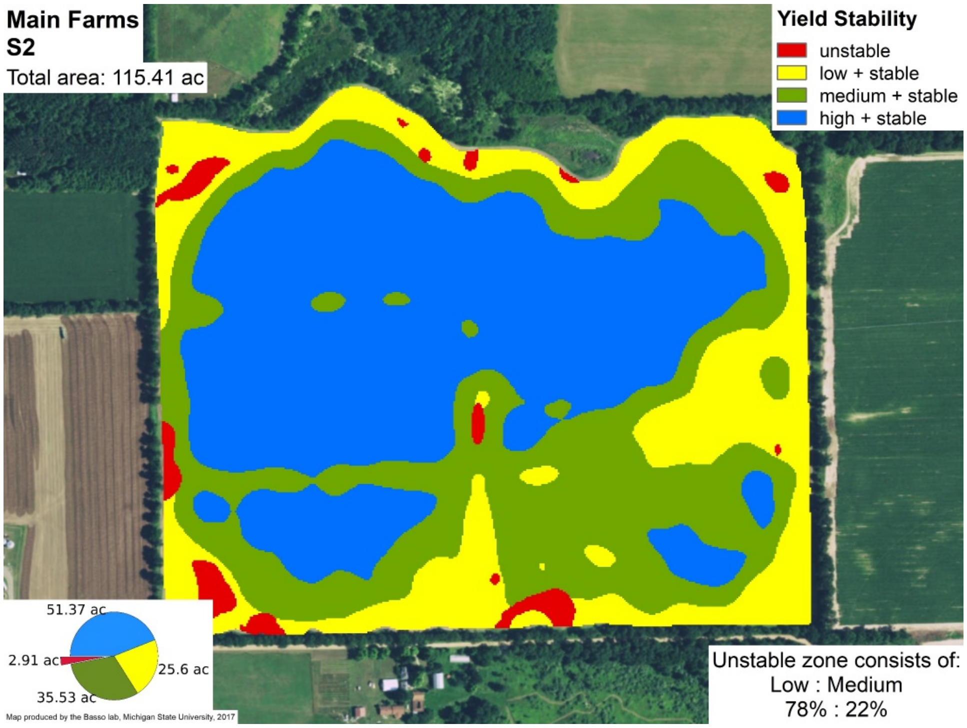

Figure 27. Stability map at S2 including 5 years of corn and 1 year of potato yield data.

Nematodes and Potatoes, the Good, the Bad and How to Win the Battle

Marisol Quintanilla-Tornel, Emilie Cole, and Kristin Poley
Michigan State University, Entomology Department, Applied Nematology Program

Potatoes are an important crop in the North Central Region and are faced with many serious fungal, nematode, and insect pest management issues. Potato Early-Die Disease Complex is the most economically important disease complex in Michigan. Our 2017 trials sought to compare different treatments for Potato Early Die complex (root lesion nematode and Verticillium wilt). We intend to continue this research and develop soil based management practices for Potato Early-Die complex. We will accomplish this through the development, evaluation, and delivery of designer composts as well as the evaluation of cross pest impacts of non-fumigant nematicides/insecticides. We will also evaluate the impact of these practices on soil biology and health.

A 2017 replicated trial compared several nematicides and compost/manure treatments for Potato Early-Die disease complex control at Michigan State University's Montcalm Research Center. There were nine treatments with five replications in a randomized block design. The treatments consisted of an untreated control, two Morgan Composting recipes at 1 ¼ tons per acre, chicken manure at 5 tons per acre, Mocap, Movento, Nematec, Nimitz, and Velum at labeled rates.

Mocap had the highest total potato yield. The yield with treatments such as composts, Velum, and Movento having yields not significantly different from Mocap. Mocap yield was significantly higher than Nematec (Table and Fig. 1). Nimitz had the second lowest yield and phytotoxicity is assumed to be the cause. If the soil application of Nimitz is not directly applied to the potatoes during planting, it is assumed that the phytotoxicity effect would be reduced.

Tubers damaged by Verticillium wilt, causing vascular discoloration, was lowest in the Velum treatment, which is a logical result, since Velum is both a fungicide and a nematicide (Table 2). Plant parasitic nematodes were lowest in the 2nd Compost type and Nimitz, while the control had the highest number of both root lesion and root knot nematodes.

This trial will be repeated in 2018 and lab and greenhouse trials will be conducted to further investigate solutions to Potato Early-Die complex.

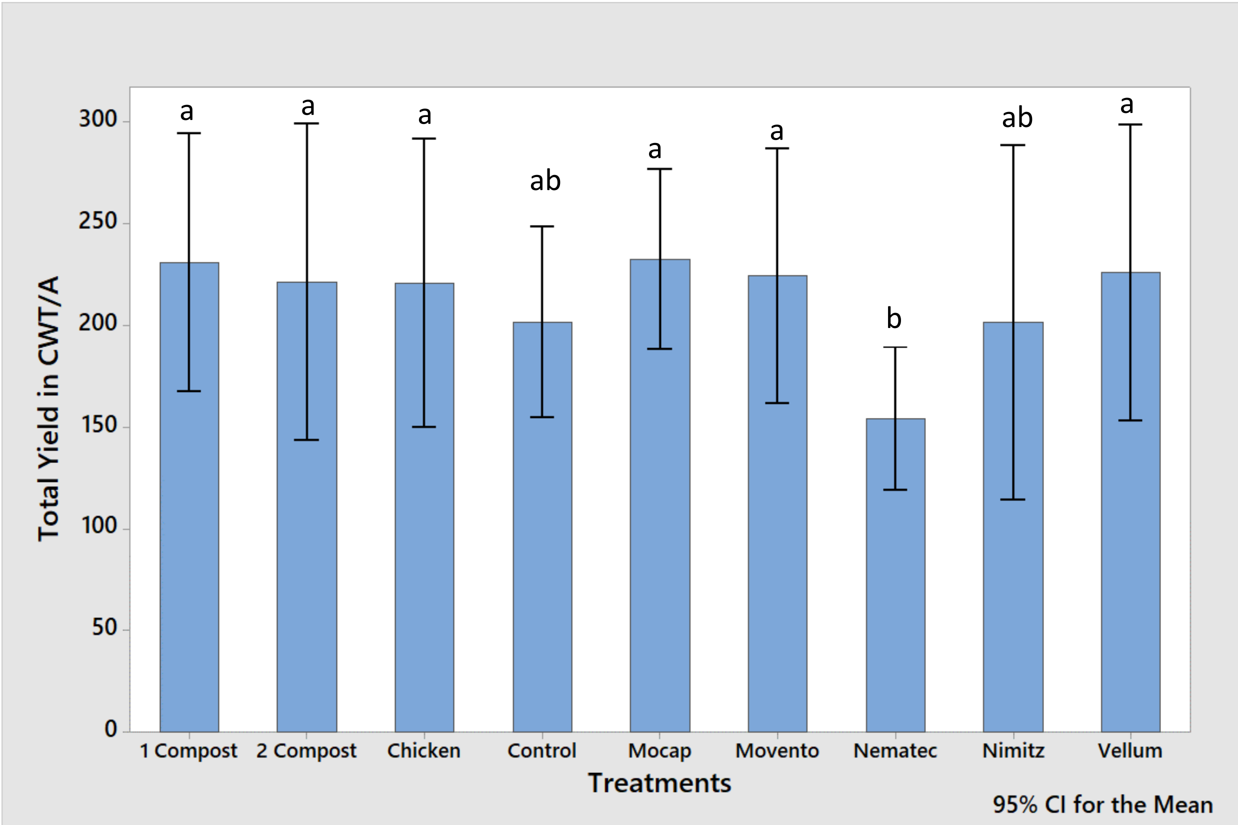

Fig. 1. Comparison of treatments for plant parasitic nematodes and Potato Early-Die disease complex on total potato yield in tons per acre. Error bars represent standard error of the mean. Grouping information using the Fisher Least Significant difference method and 95% confidence.

Table 1. Total yield in tons per acre of potatoes in a 2017 Michigan, Montcalm trial. Grouping Information Using the Fisher LSD Method and 95% Confidence

Treatments	N	Mean	Grouping	
Mocap	5	232.739	A	
1 Compost	5	230.948	A	
Vellum	5	226.022	A	
Movento	5	224.360	A	
2 Compost	5	221.348	A	
Chicken	5	220.637	A	
Control	5	201.650	A	B
Nimitz	5	201.447	A	B
Nematec	5	154.162		B

Means that do not share a letter are significantly different.

Table 2. Percent damage by *Verticillium dahliae* Vascular discoloration. The highest mean percent vascular discoloration was found in the first compost group and the lowest was found in Vellum. Grouping Information Using the Fisher LSD Method and 95% Confidence

Treatments	% Vas. Disc.	Grouping	
1 Compost	5.6	A	
2 Compost	5.0	A	B
Nimitz	4.8	A	B
Chicken	4.6	A	B
Mocap	4.6	A	B
Movento	4.4	A	B
Nematec	4.4	A	B
Control	4.2	A	B
Vellum	3.4		B

Means that do not share a letter are significantly different.

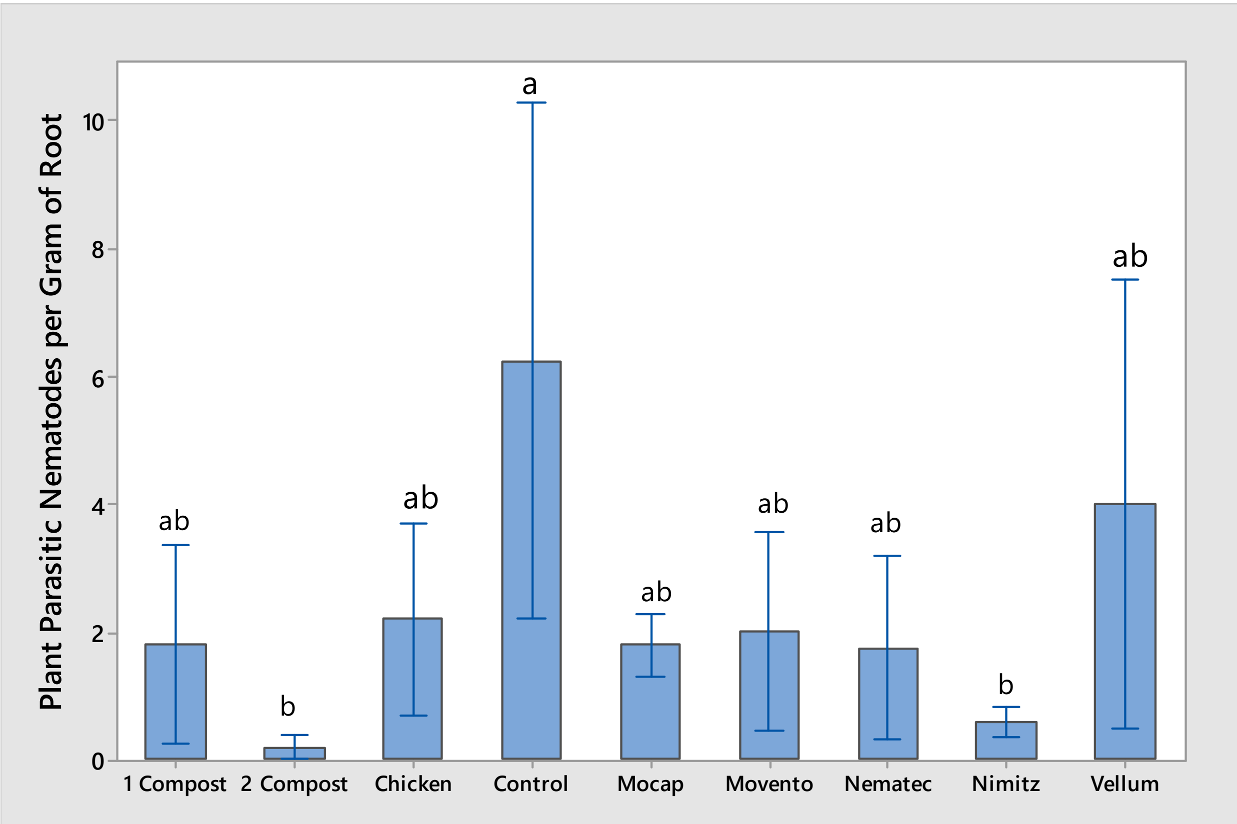

Fig. 2. Comparison of treatments for plant parasitic nematodes and Potato Early-Die disease complex on plant parasitic nematode numbers. Error bars represent standard error of the mean. Grouping information using the Fisher Least Significant difference method and 95% confidence.

2016-2017 MICHIGAN POTATO DEMONSTRATION STORAGE ANNUAL REPORT MICHIGAN POTATO INDUSTRY COMMISSION

Chris Long, Coordinator, Trina Zavislan, Anna Busch, and John Calogero

Introduction and Acknowledgements

Round white potato production for chip processing continues to lead the potato market in Michigan. Michigan growers continue to look for promising, new, round white varieties that meet necessary production and processing criteria. There are many variety trials underway in Michigan that are evaluating chipping varieties for yield, solids, disease resistance, desired tuber size profile and chipping quality with the hope of exhibiting the positive attributes of these lines to growers and processors. Extended storage chip quality and storability are of extreme importance in round white potato production. Therefore, any new chip processing varieties with commercialization potential will have storage profiles developed. Examining new varieties for long-term storage and processing quality keeps 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) Potato Demonstration Storage Facility currently consists of two structures. The first building, the Dr. B. F. (Burt) Cargill Building, constructed in 1999, allows the Michigan potato industry to generate storage and chip quality data on newly identified chip processing clones. This information helps to establish the commercial potential of new varieties. This demonstration storage facility utilizes six, 550 cwt. bulk bins (bins 1-6) that have independent ventilation systems. The Ben Kudwa Building, built in 2008, has three independently ventilated, 600 cwt. bulk bins. The first of these bulk bins, bin 7, was converted to 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 point into storage profiling that allows the industry to learn about a varieties' physical and chemical storability before advancing to the bulk bin level. A variety is evaluated for 4-6 years 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, we evaluate each variety for weight loss or shrinkage and pressure bruise. With this information, we can create the storage profile of a variety, 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 used to evaluate the post-harvest physiology of potatoes. The facility can be used to evaluate storage pathology or sprout inhibitor products. The Michigan industry recognizes the importance of controlling disease and sprout development in storage and is committed to doing research in these areas.

This fifteenth annual Demonstration Storage Report contains the results of the storage work conducted in the facility during the 2016-2017 storage season. Section I, "2016-2017 New Chip Processing Variety Box Bin Report", contains the results and highlights from our 10 cwt. box bin study. Section II, "2016-2017 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: Duane Anderson, Steve Crooks, Todd Forbush, Dennis Iott, Larry Jensen, Chris Long, Joe Luana, Mike Wenkel, Tim Wilkes, and Chase Young. The funding and financial support for this facility, and the research 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 Crooks, Crooks Farms, Inc.; Brian Sackett, Sackett Potaoes; and Tim, Todd and Chase Young, Sandyland Farms 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 Keeney, Jim Fitzgerald and Jack Corriere of UTZ Quality Foods, Inc., Hanover, PA; Jim Allen of Shearer's Foods, Inc., Brewster, OH; 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. Dave Douches and the MSU Potato Breeding and Genetics Program, Todd Forbush (Techmark, Inc), Larry Jensen (Chief Wabasis Potato Growers), Mathew Klein (Farm Manager, MSU Montcalm Research Center), and Tim and Matt Wilkes (Potato Services of Michigan). All played a role in making this facility useful to the Michigan potato industry.

Overview of the 2016 production season

The overall 6-month average maximum and minimum temperatures during the 2016 growing season in central Michigan were similar to the 15-year average of 74^{o}F and 51^{o}F respectively (Table 1). Temperatures were slightly warmer than average in August and September and slightly cooler than average in April. Extreme heat events were lower than average in 2016 (Table 2), with 10 hours over 3 days exceeding 90^{o}F during the entire summer. However high nighttime temperatures (over 70^{o}F) were slightly higher than the average.

Rainfall for April through September was 18.17 inches, which was 1.08 inches above the 15-year average (Table 3). In general early season precipitation (April-June) was below average, mid-season precipitation was above average (July-August) and late-season precipitation was above average (September).

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.
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
2013	51	33	73	48	77	55	81	58	80	54	78	48	73	49
2014	55	33	68	45	78	57	77	54	79	56	72	47	72	49
2015	58	34	71	48	76	54	80	56	77	57	77	54	73	51
2016	**53**	**32**	**70**	**45**	**78**	**53**	**82**	**59**	**85**	**60**	**78**	**54**	**74**	**51**
15-Year Average	57	35	68	45	78	55	82	58	80	57	74	50	73	50

Table 2. Six-year heat stress summary (from May 1st – Sept. 30th)*

Year	Temperatures > 90°F		Night (10pm-8am) Temperatures > 70°F	
	Hours	Days	Hours	Days
2011	14	4	174	32
2012	70	15	143	30
2013	14	3	140	28
2014	0	0	58	15
2015	3	1	66	22
2016	**10**	**3**	**147**	**31**
Average	19	4	121	26

Table 3. 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
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
2013	7.98	4.52	2.26	1.35	4.06	1.33	21.50
2014	4.24	5.51	3.25	3.71	1.78	2.35	20.84
2015	3.71	2.96	4.79	1.72	2.42	3.9	19.50
2016	**2.25**	**2.77**	**1.33**	**3.42**	**5.35**	**3.05**	**18.17**
15-Year Average	2.83	3.37	2.61	2.82	3.20	2.26	17.09

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

I. 2016-2017 New Chip Processing Variety Box Bin Report

(Chris Long, Trina Zavislan, Anna Busch, John Calogero, and Brian Sackett)

Introduction

This project evaluated new chip processing varieties from national and private breeding programs for processing quality after storage conditions. We evaluated a variety's response to pile temperature, as reflected in sucrose and glucose levels, as well as weight loss and pressure bruise susceptibility. Bin 7 contained 36, 10 cwt. boxes. We organized the 36 boxes in to six stacks of six. The box design allows air to travel in from a header, or plenum wall, through the forklift holes of each box and up through the potatoes within it. The air continues to flow up through the next box until it reaches the top and is drawn off the top of the chamber. The air is then 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 we sampled tubers for bi-weekly quality evaluations.

Procedure

In 2016, we evaluated and compared 33 new varieties to the check varieties Snowden and Lamoka. Once the varieties were chosen, 1 cwt. of each variety was planted in a single 34-inch wide row, on May 3rd at the MSU, Montcalm Research Center, Entrican, MI. We planted the varieties at a 10" in-row seed spacing. All varieties received fertilizer in the rates of: 297 lb. N/A, 130 lb P_2O_5/A and 261 lb K_2O/A. The varieties were vine killed after 129 days and allowed to set skins for 26 days before harvest on September 30th, 2016; which was 150 days after planting. We did not account for variety maturity in harvest timing due to storage and handling restrictions.

We placed approximately 10 cwt. of each variety in a box bin and stacked the boxes in bin 7. The average storage temperature for all the box bins (box bin 7) was 54.0ºF for the 2016-2017 season. At harvest, we collected nine, 20 lb. samples from each variety for weight loss and pressure bruise evaluation. We describe the varieties, their pedigree and scab ratings in Table 4. We also recorded yield, size distribution, chip quality, and specific gravity at harvest (Table 5). We graded the varieties to remove all "B" size tubers and pick-outs, ensuring the tubers began storage in good physical condition.

The storage season began September 27, 2016, and ended June 5, 2017. Bin 7 was gassed with CIPC on October 28, 2016. We began variety evaluations on October 4, 2016, followed by a bi-weekly sampling schedule until early June. We randomly selected forty tubers from each box every two weeks and sent them to Techmark, Inc. for sucrose, glucose, chip color and defect evaluation. We also evaluated pressure bruising by placing nine pressure sample bags for each variety in one of the bulk bins at the storage facility. We placed three bags at each of 3’, 8’ and 14’ from the pile floor. When that bin was unloaded, we weighed the sample bags and calculated percent weight loss. We evaluated a 25-tuber sample from each of the nine bags for the presence or absence of pressure bruise. We recorded the number of tubers and severity of bruise. All pressure bruises were evaluated for discoloration.

This report is not an archive of all the data that we generated for the box bin trial, but rather a summary of the data from the most promising lines. The purpose of this report is to present a summary of information from the best performing 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 at (517) 355-0277 or longch@msu.edu.

Table 4. 2016-17 MPIC Demonstration Box Bin Variety Descriptions

Entry	Pedigree	2016 Scab Rating*	Characteristics
Lamoka (NY139)	NY120 X NY115	0.5	High yield, mid- late season maturity, medium specific gravity, oval to oblong tuber type, low internal defects, long term chip quality
Manistee (MSL292-A)	Snowden X MSH098-2	2.0	Average yield, scab resistance similar to Snowden, medium specific gravity, long storage potential, uniform, flat round tuber type, heavy netted skin
Snowden (W855)	B5141-6 X Wischip	2.5	High yield, late maturity, mid-season storage, reconditions well in storage, medium to high specific gravity
AF4648-2	NY132 X Liberator	1.5	High yield potential, common scab resistant, high specific gravity, low internal defects
B2727-2	B0766-3 X B2135-163	1.0	In the 2017 SNAC Trial, smaller tuber size profile, some susceptibility to shatter bruise
CO07070-10W	B0766-3 X CO00188-4W	0.0	High yield, medium vine vigor and maturity, high specific gravity
CO07070-13W	B0766-3 X CO00188-4W	1.5	Vigorous vine, early maturing and tuber bulking, medium yield and specific gravity. In the SNAC trial.
MSM246-B	MSE274-A X NY115	2.0	Average yield, medium specific gravity, common scab resistance similar to Snowden, long term chip quality similar to Manistee
MSR127-2	MSJ167-1 X MSG227-2	2.0	Scab resistant, high specific gravity, good chip quality from storage, above average yield potential, medium-late maturity. In the 2017 SNAC trial
MSV033-1	Beacon Chipper X MSJ147-1	1.5	High yield potential, common scab susceptible, high specific gravity
MSV241-2	Marcy X Mega Chip	1.5	Scab resistant, high yield potential and specific gravity. High percent US #1 tubers
MSV301-2	MSN105-1 X MSP197-1	0.0	Scab resistant with high yield potential and specific gravity

MSV313-2	MSN238-A X OP	0.5	High yield potential, large round tubers with smooth shape, scab resistant, potential storage chipper. Currently in Potatoes USA Fast Track trial
MSV383-B	Pike X MSN238-A	1.0	Scab Resistant chipper with high specific gravity, smooth, round attractive tuber type with storage potential
MSV358-3	MSP239-1 X OP	0.5	Scab resistant with high specific gravity, has chip storage potential from 50F, in Fast Trac program
MSV507-40	Tundra X Kalkaska	1.5	Highly scab resistant, long term storage chipper with high specific gravity, currently in NCPT
MSW474-1	MSN190-2 X MSP516-A	0.5	Scab resistant with storage potential, currently in NCPT, high yield potential
MSW485-2	MSQ070-1 X MSR156-7	0.5	Scab resistant with moderate late-blight resistance, high specific gravity and attractive tuber shape, in Fast Track program
MSW509-5	Kalkaska X Marcy	0.5	Scab resistant with high yield potential, smooth attractive tubers, not for long term storage
MSX540-4	Saginaw Chipper X Lamoka	0.0	Medium/high yield potential, common scab, late blight and PVY resistant, high specific gravity, currently in Fast Track program
NC0349-3	Snowden X B0564-9	2.0	Medium to late maturity, round tuber shape, medium specific gravity, netted skin, good chip color, some potential susceptibility to internal defects
ND7519-1	ND3828-15 X W1353	0.5	High specific gravity, medium to high yield potential, medium vine maturity, round smooth skinned tubers
NDTX081648CB-13W	ND8456-1 X ND7377CB-1	1.0	In the 2017 SNAC trial. High yield potential, good gravity, medium maturity
NY152 (NYH15-5)	B38-14 X Marcy	1.0	High yield potential, medium specific gravity, moderate resistance to common scab, medium-late maturity. In Fast Track program
NY153	Waneta X Pike	2.0	Moderate to high yield potential, low incidence of internal defects

NY154 (NYH15-17)	B38-14 X Marcy	0.0	High yield potential, high specific gravity, moderate common scab resistance, late maturing
NY157	White Pearl X Marcy	0.5	High yield potential, low internal defects, medium specific gravity, moderate common scab resistance
NY162 (NYK31-4)	NYE106-2 X NYE48-2	2.0	High percent US #1 tubers, good internal quality, susceptible to common scab
NYK27-1	Ivory Crisp X NYE48-2	0.0	Possible common scab resistance, average yield potential, susceptible to shatter bruise
NYL1-7	NYD50-8 X NYE48-2	1.5	Moderate to high yield potential
NYL7-2	NYE50-8 X NYE48-2	0.5	Possible common scab resistance, larger tuber size profile
TX09396-1W	Atlantic X Lamoka	2.0	Large tuber size, nice skin, moderate to high yield potential
W6822-3	White Pearl X Dakota Pearl	1.0	Average yield, medium-late maturity, high specific gravity, susceptible to internal defects, moderate common scab resistance
W8822-1	Fasan X Tundra	0.0	High specific gravity, tolerant to PVY, late maturity, long storage potential, cream to yellow colored flesh depending on environmental conditions. In Fast Track program.

*Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible. Common scab data and qualitative descriptions provided by Potato Outreach Program (P.O.P.), MSU Potato Breeding and Genetics Program and other potato breeding programs.

Table 5. 2016 MPIC Box Bin Processing Potato Variety Trial
MSU Montcalm Research Center, Montcalm County, MI

Planting: 5/3 Vine Kill: 9/9 Harvest: 9/30

GDD_{40}: 3537[8]

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[3]	RAW TUBER QUALITY (%)[2] HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS[7]
TX09396-1W	618	659	94	3	63	31	3	1.081	1.0	0	60	20	0	2.0	3.0	4.0	Sticky stolons
MSR127-2	606	641	94	5	88	6	1	1.076	1.0	0	60	0	0	2.0	3.0	4.0	
Snowden	**510**	**596**	**85**	**14**	**76**	**9**	**1**	**1.073**	**1.0**	**10**	**40**	**10**	**0**	**2.5**	**3.0**	**3.0**	
W8822-1	480	539	89	9	84	5	2	1.081	1.5	0	10	0	0	0.0	3.5	2.5	Heavy dark russet skin type and light yellow flesh
MSX540-4	478	539	89	9	82	7	2	1.081	1.0	0	40	10	0	0.0	3.0	4.0	
MSV313-2 (Low N)	472	532	89	9	89	0	2	1.073	1.0	0	40	0	0	1.0	2.0	3.5	
MSW474-1	459	566	81	18	77	4	1	1.075	1.0	0	10	0	0	0.5	3.0	3.5	Deep apical eye
Manistee	457	491	93	6	76	17	1	1.072	1.0	0	20	0	0	2.0	2.5	2.0	Flat apical stem end tuber type, netted skin
AF4648-2	457	480	95	4	74	21	1	1.076	1.0	30	60	0	0	1.5	3.0	3.0	
MSW485-2	452	544	83	17	82	1	0	1.088	1.0	0	20	0	0	0.5	3.5	3.0	Tr sticky stolons
MSV033-1	447	505	88	7	63	25	5	1.073	1.0	0	40	0	0	1.5	4.0	3.0	Growth cracking, sticky stolons, nice chip color
NY154	444	497	89	7	72	17	4	1.076	1.0	0	50	0	0	0.0	3.5	3.5	
NYL1-7	436	483	90	9	89	1	1	1.067	1.0	0	40	0	0	1.5	3.5	1.5	
MSW509-5	423	483	87	11	81	6	2	1.074	2.0	0	50	0	0	0.5	4.0	2.5	
MSV358-3	403	493	82	16	82	0	2	1.073	1.0	0	10	0	0	0.5	2.5	1.5	Uniform tuber type, moderate netted skin
NY153	398	462	86	13	82	4	1	1.081	1.0	0	20	0	0	2.0	3.0	2.5	
Lamoka	**378**	**447**	**85**	**11**	**76**	**9**	**4**	**1.075**	**1.0**	**0**	**70**	**0**	**0**	**0.5**	**3.0**	**2.5**	**Flat oval tuber type**
MSM246-B	366	403	91	9	82	9	0	1.080	1.0	0	20	0	0	2.0	3.0	3.0	
NC0349-3	360	415	87	13	75	12	0	1.071	1.0	40	70	0	0	2.0	2.0	3.0	
NDTX081648CB-13W	359	427	84	14	83	1	2	1.085	1.5	0	30	0	0	1.0	4.0	2.5	
NYK27-1	358	431	83	16	68	15	1	1.072	1.0	0	20	0	10	0.0	2.5	2.5	Severe shatter bruising, tr black spot bruise
MSV301-2	353	408	87	12	84	3	1	1.066	1.0	0	0	0	0	0.0	3.5	1.5	
Snowden (Low N)	352	399	89	10	85	4	1	1.072	1.0	0	40	0	0	2.0	2.5	3.0	Tr pinkeye, deep apical eye

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[3]	RAW TUBER QUALITY (%)[2] HH	VD	IBS	BC	SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS[7]
W5955-1	339	391	87	11	76	11	2	1.072	1.0	0	50	0	30	0.0	3.0	3.0	Excellent chip color and quality
MSV313-2	336	350	96	3	44	52	1	1.068	1.0	0	10	0	0	0.5	2.5	3.0	
ND7519-1	332	438	76	22	75	1	2	1.079	1.0	0	10	20	0	0.5	4.0	2.0	Small uniform tuber type
NY162	319	377	85	13	80	5	2	1.067	1.0	0	10	0	0	2.0	2.0	3.0	
MSV507-040	315	344	92	2	64	28	6	1.073	1.0	0	40	0	0	1.5	2.0	2.0	Deep apical eyes
MSV241-2	303	330	92	6	87	5	2	1.083	1.0	0	10	10	0	1.5	1.5	3.0	
NYL7-2	269	296	91	7	62	29	2	1.067	1.0	0	10	0	0	0.5	3.0	2.5	Growth cracking
CO07070-13W	241	322	75	24	75	0	1	1.075	1.0	0	0	0	0	0.0	4.5	1.0	Small overall tuber type
NY152	240	391	61	39	61	0	0	1.078	1.0	0	10	0	0	1.0	3.5	2.0	Small overall tuber type
MSV383-B	234	318	74	11	67	7	15	1.074	1.0	0	0	0	0	1.0	3.0	2.0	Severe growth cracking and mishapened tubers
CO07070-10W	199	301	66	34	66	0	0	1.083	1.0	0	0	0	0	1.5	3.5	1.0	
NY157	195	266	73	26	66	7	1	1.070	1.0	0	30	0	0	0.5	3.5	3.0	Severe shatter bruise
B2727-2	175	276	63	37	63	0	0	1.077	1.0	0	20	0	0	1.0	3.0	2.0	
W6822-3	162	292	56	44	56	0	0	1.081	1.0	0	40	0	0	1.0	4.0	2.0	Small overall tuber type
MEAN	**371**	**436**	**84**	**14**	**74**	**10**	**2**	**1.075**	**1.1**	**2**	**29**	**2**	**1**	**1.0**	**3.1**	**2.6**	tr = trace, sl = slight, NA = not available

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
(percentage of tubers out of 10)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3]CHIP COLOR SCORE - Snack Food Association Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

[5]VINE VIGOR RATING
Date: 10-Jun-16
Ratings: 1 - 5
1: Slow Emergence
5: Early Emergence (vigorous vine, some flowering)

[6]VINE MATURITY RATING
Date: 24-Aug-16
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine, some flowering)

Planted: 3-May-16
Vines Killed: 9-Sep-16
Days from Planting to Vine Kill: 129
Seed Spacing: 10"
Fumigation: No

[4] COMMON SCAB RATING
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

[7]ALLIGATOR HIDE RATING
0.0: No incidence of raised corky skin spots
2.0: Unmarketable corky skin spots
5.0: Multiple, large corky skin lesions, covering a significant amount of surface area of the tuber

[8]MAWN STATION: Entrican
Planting to Vine Kill

Results: 2016-2017 Chip Processing Box Bin Highlights

Hodag (W5955-1)

This University of Wisconsin variety, recently named ‘Hodag’, has been evaluated in the Box Bin Trial for three years. The specific gravity was average at 1.072 at harvest and the yield was slightly below average at 339 cwt/A US#1 (Table 5). Hodag may have been immature at storage, as pre-harvest sucrose increased from 0.671 percent to 0.776 percent between August 25th and September 6th. This variety exhibited mid-season maturity and scab resistance. It had excellent out-of-the-field chip quality, with a 1.0 chip score. At the first sample date on October 4, 2016 tuber samples tested at 0.613 (X10) percent sucrose and 0.002 percent glucose with a bin temperature of 60ºF. As temperature initially cooled, sucrose and glucose levels increased, peaking at 0.660 (X10) percent and 0.003 percent respectively in early December at 53.6ºF. Temperature increased to 53.8ºF and sucrose and glucose concentrations gradually decreased. These concentrations remained relatively stable between December and early March. During this time, sucrose was between .381 and .443 percent (X10), while glucose was between .002 and .001 percent. From the beginning of storage to late March, chip quality was excellent with a low percentage of total defects. As temperature increased to 54°F in early April, glucose and sucrose concentrations rose to .022 percent and 1.284 percent (X10) respectively. This corresponded to an increase in undesirable color to 38%. The last acceptable chip quality sample from storage was on March 27, 2017 (Figure 1). Hodag has strong potential for commercialization in Michigan, due to many positive attributes. This includes yield potential, tolerance to common scab, excellent chip quality, and nice tuber shape.

Figure 1. Storage chip sample on March 27, 2017.

MSR127-2

This Michigan State University (MSU) chip processing variety has repeatedly demonstrated common scab tolerance and has a uniform round tuber type. The specific gravity for this variety was 1.076, above the trial average of 1.075. In 2016, we recorded a US#1 yield of 606 cwt/A for this variety, well above the trial average of 371 cwt/A (Table 5). MSR127-2 appears to have a medium to late maturity with a good set of uniform size tubers. The internal quality was good with only vascular discoloration (60%) reported at harvest in the raw tubers. The out-of-the-field chip color was excellent, scoring a 1.0 SFA score. On October 4, 2016, MSR127-2 had a sucrose value of 0.445 (X10) percent and a glucose value of 0.006 percent. As temperature decreased, sucrose and levels remained relatively stable. The temperature stabilized at 53.8ºF in December, and remained between this value and 54ºF for the rest of the storage season. Concentrations gradually rose, beginning in March, reaching 0.756 (X10) percent in early May. Glucose levels remained stable, fluctuating between 0.001-0.003 percent for the majority of the storage period with a small peak to 0.008 percent when storage temperatures were the coldest on March 27th at 52.8ºF. Glucose levels rose again on May 7th to 0.015 percent. MSR127-2 appears to have good mid-season chip processing quality and similar late-season chip quality as observed in the previous storage year. This variety will be evaluated in the bulk storage bin environment in 2017.

Figure 2. Storage chip sample from April 18, 2017.

MSW485-2

In 2016, this Michigan State University variety had a US#1 yield of 452 cwt/A with the highest specific gravity for the Box Bin trial at 1.088 (Table 5). We observed 30% vascular discoloration with no other internal defects. This variety may have some common scab susceptibility with a scab rating of 0.5. It was mature at harvest, with a pre-harvest specific gravity of 1.086 and 0.492 percent (X10) sucrose on August 30th. On October 4, 2016, this variety had a sucrose level of 0.503 (X10) percent and a glucose level of 0.001 percent. The sucrose levels gradually decreased to 0.277 (X10) in early January. When the bulk bin temperature stabilized at 54ºF, sucrose concentrations decreased to 0.002 percent, with a small increase to 0.003 percent corresponding to a temperature drop to 52.8ºF. Begin in April, the temperature was increased to 54°F, and sucrose rose, reaching 1.011 percent (X10) in June. Glucose also rose during this time, with a final reading of 0.011 percent. Chip quality was good over the storage season, with no undesireable chip color reported and a low percentage of internal defects. Overall, this variety performed well in storage with acceptable chips through mid-May (Figure 3). We will continue to evaluate this variety in 2017 in bulk bin storage.

Figure 3. Storage chip sample from May 16, 2016.

NY152

This Cornell variety had a smaller tuber size profile with 39% B-sized potatoes in 2016, a below average US #1 yield of 240 cwt/A, and a specific gravity of 1.078. It had good internal quality and an excellent chip color out of the field. It was slightly immature at harvest, with a small increase in sucrose measured between two pre-harvest panels. On October 4, 2016, it had 0.778 percent (X10) sucrose, which decreased to 0.215 in March. Sucrose gradually rose to 0.372 percent (X10) until the end of storage in early June. Glucose concentration remained relatively constant during storage, beginning at 0.002 percent, decreasing to 0.001 percent between December and April, and increasing to 0.003 percent in June. NY152 has consistently excellent chip quality, with good internal color and a low percentage of defects observed, even late in the season. Combined with an attractive tuber size profile, it performs well in Michigan despite a lower specific gravity. Figure 4 displays good chip quality on June 6, 2017.

Figure 4. Storage chip sample from June 6, 2017.

Snowden

This variety was included as a commercial standard for the 2016-2017 Box Bin Trial. The yield was above average at 510 cwt./A US#1 with an below average specific gravity of 1.073 (Table 2). On October 4, 2016, this variety was unloaded into storage and analyzed for sucrose and glucose concentrations. As temperature decreased, sucrose also decreased from 0.737 to 0.479 (X10) percent until January. Glucose fluctuated between 0.002 percent and .003 percent during this time from harvest to January. Snowden displayed characteristics of senescence sweetening with rising glucose percentages from .002 percent on January 3rd to 0.019 percent on March 13th when it was removed from storage, at a stable bin temperature of 53.8ºF. Sucrose concentrations also increased from January to the end of storage in March. Chip quality was initially acceptable with low percentages of undesirable chip color observed, but both internal color and total defects rose over time, ending with many tubers displaying dark coloration or other defects in March The chip picture below depicts Snowden during its last acceptable chip quality date taken on February 13, 2017.

Figure 5. Storage chip sample from March 7, 2016.

II. 2016 - 2017 Bulk Bin (500 cwt. Bin) Report

(Chris Long, Trina Zavislan, Anna Busch, John Calogero, Jolyn Rasmussen, and Brian Sackett)

Overview and Objectives

The goals of the MPIC Storage and Handling Committee for the 2016-2017 bulk bin storage season were: 1. to develop optimal storage profiles for Hodag (W5955-1) and MSR127-2, two promising common scab resistant varieties suited to production in Michigan, 2. evaluate two temperature ramping strategies in Hibernate (Y9). Hibernate (Y9) is a variety developed by the J.R. Simplot Company, and 3.to study the effects of two different temperatures on the storage quality of Manistee potatoes.

Procedure

Each bin was filled under contract with potato producers in the state of Michigan. The MPIC paid field contract price for the potatoes to be delivered to the demonstration storage, excluding bins five and six, where were purchased by Simplot. 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 54ºF, which in most cases, is warmer than the corresponding bulk bin of the same variety. 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 tubers might physiologically age. All of the bulk bins were gassed with CIPC on November 7th, except for bins 8 and 9, which were gassed on the 28th.

Bulk bin assignments are below:

1: Hodag (Sandyland Farms)

2, 3, and 4: MSR127-2 (Sackett Potatoes)

5 and 6: Hibernate (Y9) (Sandyland Farms)

7: Box Bins

8 and 9: Manistee (Crooks Farms)

We began sugar monitoring the day tubers were loaded into storage and sampled tubers on a two-week 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 allows us to take samples from the pile three feet above the bottom of the pile. Pressure bruise evaluation began by collecting nine, 20 to 25 lb. tuber samples as each bin was being filled. Three samples were placed at each of three different levels within the bulk bin pile at 3, 8, and 14 feet from the storage floor.

We evaluated the pressure bruise samples 3 to 5 days after the bin was unloaded. We randomly selected a set of 25 tubers from each bag and visually inspected for pressure bruising. By removing the tuber skin with a knife, we evaluated the discoloration for each flat spot. A visual rating established presence or absence of flesh color (blackening of flesh). We calculated percent weight loss in each tuber sample as it was removed from the storage.

Hodag Storage Trial (Bin 1)

Hodag, a promising variety from the University of Wisconsin, has commercialization potential in Michigan due to excellent chip quality, resistance to common scab, and long-term storage potential. The purpose of this bulk bin experiment was to evaluate glucose and sucrose reaction during pile cooling to 48ºF. Cooling occurred at a rate of 0.4ºF per day to 52ºF, then the rate was adjusted to 0.2ºF per day until the temperature reached 48ºF.

We filled Bin 1 with Hodag on October 4, 2016. The seed was planted in Howard City, MI on May 20, 2016 and vine killed on August 22, 2016 (95 DAP, GDD_{40} 2758). This planting was harvested on October 3, 2016, 136 days after planting. The pulp temperature for tubers at the time of bin loading was 61ºF. Bins 1 was gassed with CIPC on November 8, 2016. It was unloaded on May 9, 2017 and shipped to Herr Foods, Nottingham , PA.

Results

Bulk Bin 1, Hodag (GDD_{40} 2758, 48ºF)

Chip quality out of the field was acceptable with 28.7% total defects reported on the first sample date, October 4, 2016. Defects are reported by Techmark, Inc, and are determined using slices cut from stem to bud end. On this date, sucrose and glucose concentrations were 0.462 percent (X10) and 0.002 percent respectively with a pulp temperature of 61ºF. The tuber quality at bin loading was good with 92% bruise-free.

Hodag was physiologically and chemically immature at bin loading as indicated by an increase in glucose concentration between two preharvest panels, as well as an increase in glucose between loading and early December to 0.559 percent (X10). During this time period, sucrose levels increased, rising to a high of 0.005 percent. After December, sucrose levels fluctuated through early March then decreased to a final value of 0.404 percent (X10) at bin unloading. Once the bin reached the target temperature of 48ºF, glucose decreased gradually to 0.002 percent in March, then rose to 0.005 percent at bin unloading. During storage, internal color was good, with a high of 4.1 percent undesirable color reported in March. Total defects were low overall, ranging from 3.4 percent to 30 percent.

Figure 6. Bulk bin 1 out of the field chip sample on 10/4/2016 and final chip sample on 5/9/17.

On May 10, 2017 the potatoes were processed by Herr Foods in Pennsylvania. Upon arrival, the processor noted a few green tubers and pressure bruise. Some of the tubers were oversize, oblong, or misshapen, but they had a nice skin set and appearance. Processing specific gravity was 1.081 with 5.4 percent external defects and 8.1 percent internal defects observed. Chip color was good with an Agtron score of 62.5. Some chip quality notes included a few chips with colored centers, or burnout, and some bruising.

Figure 7. Hodag potatoes at Herr Foods before and after chipping on 5/10/17.

Table 6. 2016-2017 PRESSURE BRUISE DATA Bulk Bin #1 Hodag (Howard City, MI)								
Location[1]	Average Weight Loss (%)	Average Number of External Pressure Bruises Per Tuber[2]				Average % of Total Tuber Number		
		0	1	2	3+	Without Bruise	Bruised (No Color)	Bruised with Color[3]
14'	5.02	8.00	5.67	6.67	4.67	32.0	68.0	0.0
8'	4.54	6.00	4.33	7.67	7.00	24.0	76.0	0.0
3'	5.88	3.33	7.00	6.33	8.33	13.3	86.7	0.0
OVERALL AVERAGES	**5.15**					**23.1**	**76.9**	**0.0**

[1] Feet above the bin floor.
[2] A Sample of 25 tubers randomly selected. Each tuber was first evaluated for the number of visual pressure bruises 0, 1, 2, 3+.
[3] A cut slice was removed just below the skin of each bruised area. If any flesh was darkened, it was scored as a tuber "with color".

Loaded	10/4/16	Pulp Temp. (at Filling)	61.0ºF		
Unloaded	5/9/17	Target Storage Temp.	50.0ºF	End Temp.	50.0ºF

MSR127-2 Storage Trial (Bins 2-4)

This Michigan State University Variety had commercialization potential in Michigan due to high yield potential, a higher percentage of US #1 tubers, and good chip color. These three bulk bins were filled with potatoes grown by Sackett Potatoes in Mecosta, MI. All of the potatoes were planted on May 6, 2016, and vines were killed on August 29, 2016 (115 DAP, GDD_{40} 3145). At harvest the pulp temperature was 58ºF with 60 percent, 75 percent, and 72 percent bruise free potatoes for bins two, three, and four, respectively. The potatoes were physiologically and chemically mature at harvest, and were loaded on September 28, 2016. Bins 2 and 3 were treated twice with CIPC on November 8, 2016. These bins were designed to study chip quality and potato storability under two different long-term storage temperatures and one short-term storage protocol.

Results

Bulk Bin 2, MSR127-2 (GDD_{40} 3145, 50ºF)

The potatoes in this bulk bin were cooled to 50^{o}F for the storage season. Sucrose concentrations gradually decreased as the pile was cooled down, beginning at 0.770 percent (X10) and decreasing to 0.344 percent (X10) on December 19, 2016. Concentrations rose slightly through early March, and rose again as the bin temperature was increased in late April. The initial glucose concentration was 0.002 percent, which rose to 0.005 percent in the month after bin loading, but then decreased to 0.003 percent. On February 27, 2017, glucose was 0.006 percent, corresponding to a slight increase in bin temperature.

Chip quality was good during storage, with low percentages of undesirable color reported. Internal color was also acceptable, with the highest reading of 11.8 percent taken at the last chip date on May 18, 2017.

Figure 8. Bulk bin 2 out of the field chip sample on 9/28/16 and last chip sample on 5/18/17

The potatoes were shipped to Utz Quality Foods, Inc., and were chipped by the processor. Utz recorded 17 percent total defects, 15 percent internal and 2 percent external, and a final specific gravity of 1.082.

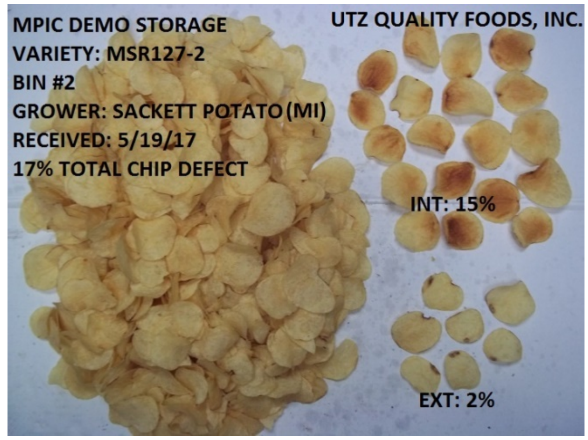

Figure 9. Bulk bin 2 Utz chip sample on 5/19/17.

Bulk Bin 3, MSR127-2 (GDD_{40} 3145, 48ºF)

This bulk bin was cooled at a rate of about 0.2ºF per day to 48ºF to study how the storage temperature affects chip quality and longevity. Free moisture was observed in the north plenum of this bin on December 19, 2016, and the humidicell was adjusted. Sucrose concentration fluctuated during the storage season, with an initial concentration of 0.770 percent (X10), reaching its lowest value of 0.413 percent (X10) on January 3, 2017, and slowly increasing to a final concentration of 0.918 percent (X10) at bin unloading. Sucrose was somewhat variable, with values above 0.005 percent measured on January 16, February 27, and April 10, prior to temperature increase in the bin, which began on April 25, 2017.

Chip quality in bin three was comparable to chip quality in bin two with approximately the same percentage of undesirable color, internal color, and total defects observed.

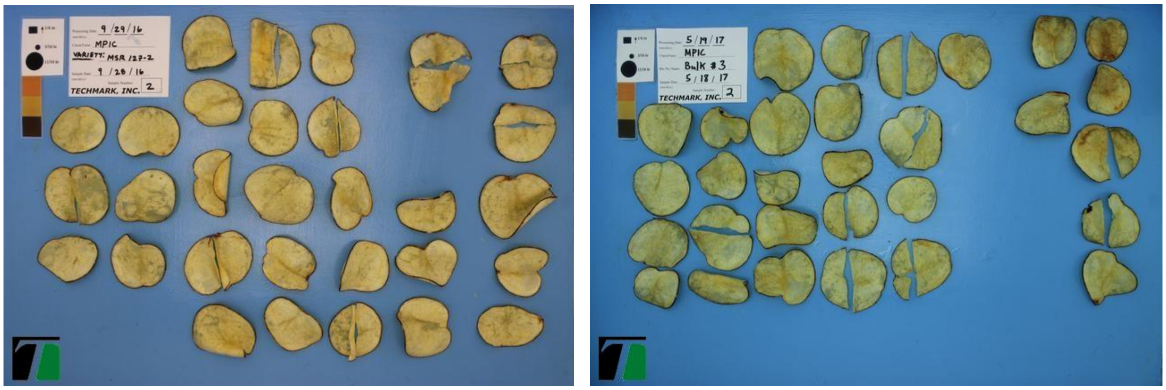

Figure 10. Bulk bin 3 out of the field chip sample on 9/28/16 and last chip sample on 5/18/17.

The potatoes were shipped to Utz Quality Foods and were chipped by the processor. Utz recorded 14 percent total chip defects, 11 percent internal and 3 percent external, with a final specific gravity of 1.080.

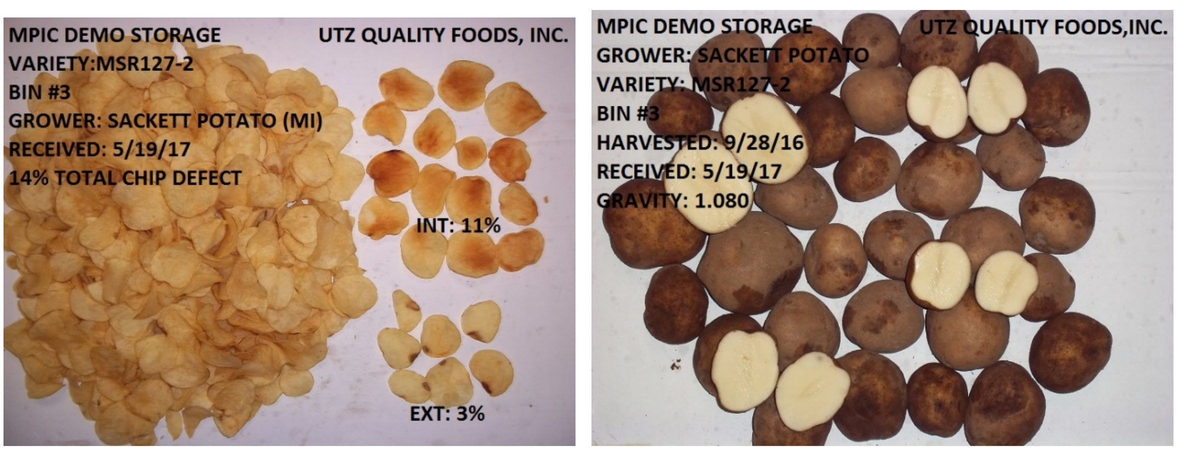

Figure 11. Bulk bin 3 Utz chip sample on 5/19/17.

Bulk Bin 4, MSR127-2 (GDD_{40} 3145, 57ºF)

These potatoes were stored between September 28, 2016 and October 19, 2016. The initial pulp temp was 58ºF, and the potatoes were stored at 57.6ºF. These potatoes were kept warm in anticipation of early shipping. A “sugar hangover,” or increase in glucose as the bin cools was observed, and Better Made, which processed this bin, noted poor chip color and quality. Techmark Inc. noted 32.8 percent defects in this sample.

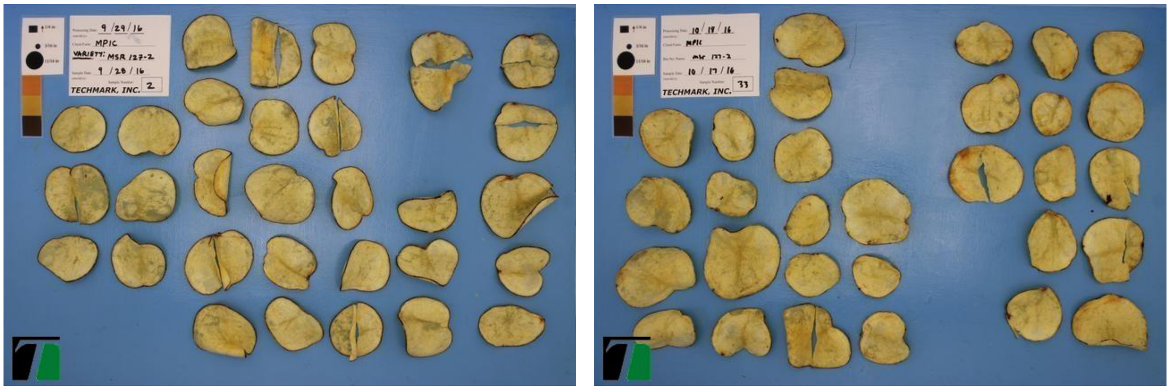

Figure 12. Bulk bin 4 out of the field chip sample on 9/28/16, and last chip sample on 10/17/17.

On October 20, 2016 the potatoes were processed at Better Made Snack Foods.
The processor noted a trace of pitted scab and some vascular discoloration, as well as a low percentage of stem end defects and bruising. The chip sample had 9.3 percent external defects, 1.2 percent internal defects, and 1.4 percent stem end defects. While Chip quality was acceptable, chip color was marginal.

Figure 13. MSR127-2 potatoes before and after chipping at Better Made Snack Foods on 10/20/2016.

Table 7. 2016-2017 PRESSURE BRUISE DATA Bulk Bin #2 and 3 MSR127-2 (Mecosta, MI)								
Location[1]	Average Weight Loss (%)	Average Number of External Pressure Bruises Per Tuber[2]				Average % of Total Tuber Number		
		0	1	2	3+	Without Bruise	Bruised (No Color)	Bruised with Color[3]
14' Bin 2	4.46	4.00	9.33	6.33	5.33	16.0	82.7	1.3
8' Bin 2	7.36	3.50	6.00	9.50	6.00	14.0	74.0	12.0
3' Bin 2	6.18	3.00	11.00	6.50	4.00	12.0	72.0	14.0
OVERALL AVERAGES	**6.00**					**14.0**	**76.2**	**9.1**
14’ Bin 3	4.29	2.00	8.33	9.67	5.67	8.0	89.3	5.3
8’ Bin 3	5.00	5.00	2.00	9.00	8.00	6.7	18.7	6.7
3’ Bin 3	7.29	2.33	4.00	7.33	11.33	9.3	68.0	22.7
OVERALL AVERAGES	**5.53**					**8.0**	**58.7**	**11.6**

[1] Feet above the bin floor.
[2] A Sample of 25 tubers randomly selected. Each tuber was first evaluated for the number of visual pressure bruises 0, 1, 2, 3+.
[3] A cut slice was removed just below the skin of each bruised area. If any flesh was darkened, it was scored as a tuber "with color".

Loaded	10/4/16	Pulp Temp. (at Filling)	61.0ºF		
Unloaded	5/9/17	Target Storage Temp.	50.0ºF (2) 48.0ºF (3)	End Temp.	51.6ºF

Hibernate (Y9) Simplot Storage Trial (Bins 5 and 6)

A variety developed by Innate®, Hibernate (Y9), was grown at Sandyland Farms in 2016. Bins 5 and 6 were loaded with these potatoes on September 27, 2016 with a pulp temperature of 58ºF. Both were treated with CIPCon November 8, 2016. Bulk bin 5 was unloaded on June 12, 2017, while bulk bin 6 was unloaded on June 7, 2017. After initial cooling, the temperatures of the bins were changed at different rates to study the effect of a “fast ramp” vs “slow ramp” temperature change. Storage regimes selected for these research bins were designed to identify storage thresholds. To understand the limits of Hibernate in storage, aggressive temperature targets and ramping rates were employed. Consequently, the bins required reconditioning of sucrose and glucose by warming. The potatoes were processed at Saratoga Foods.

Results

Bulk Bin 5, Hibernate (Y9) (GDD_{40} 2757, 42ºF)

Bulk bin 5 was cooled to 46ºF by December 8, 2016, about ten weeks after bin loading. It was then cooled at a rate of 0.2ºF per day until it reached 42ºF in late January, and remained at this temperature for about one month. Beginning in February the temperature was gradually increased at a rate of 0.2ºF per day until it reached 52.8ºF on April 28, 2017. The initial sucrose concentration at bin loading was 0.639 percent (X10), which increased through April 2017 to a high of 4.042 percent (X10). Sucrose levels decreased after April 4, when the bin was warmed from 44 ºF to46 ºF Sucrose then trended upward beginning in late May, suggesting the onset of senescent sweetening. Glucose concentrations gradually increased toward the end of the storage season with a concentration of 0.012 percent in March, suggesting a delayed response of the elevated sucrose. The glucose concentration decreased with warming through June with a final value of 0.006 percent.

Chip quality was initially good with a low percentage of total defects reported from bin loading to mid-January. After this time, internal color and total defects increased with 86.3 percent total defects reported in April and 88.1 percent reported in June. Hibernate can have elevated sucrose with low glucose because the conversion of sucrose to glucose is slower in Hibernate. Elevated sucrose may caramelize in certain fry processes with low finished chip moisture, affecting color and leading to more defects.

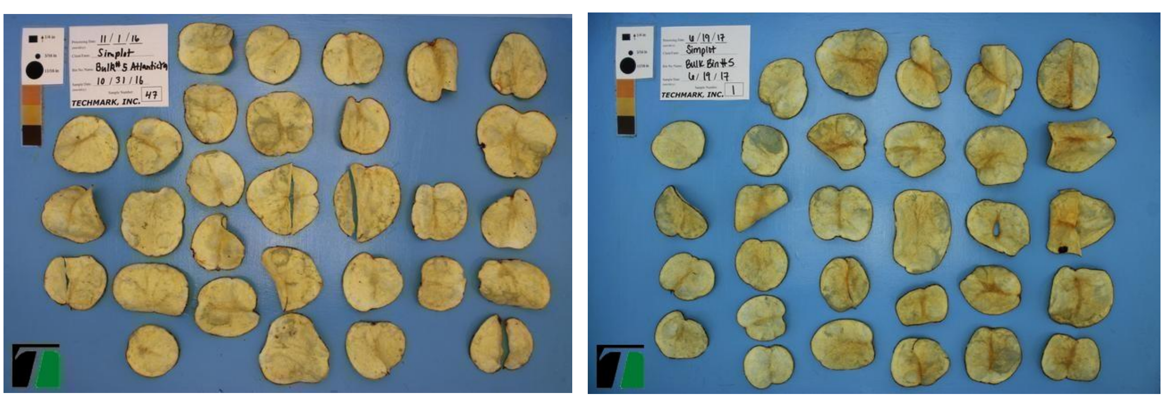

Figure 14. Bulk bin 5 first chip sample on 10/31/16, and last chip sample on 6/19/17.

Bulk Bin 6, Y9 (GDD_{40} 2757, 44ºF)

Bulk bin 6 was the slow ramp treatment in this study, and temperature was decreased more slowly compared to bin 5 and had a target temperature of 44ºF. It was cooled at different rates to reach a temperature of 47ºF in late December. After this time, it was cooled in 0.2ºF increments until it reached 44ºF in mid-January. Beginning in March, the temperature was increased by 0.2ºF per day until it reached 46 ºF mid-March. Beginning April 20, it was ramped to 52ºF and held until bin unloading on June 7, 2017.

Similar to bin 5, the sucrose concentrations where highest in the potatoes during and shortly after the coldest part of the storage season. However, this increase was less pronounced in bin 6, where the highest sucrose concentration prior to bin reconditioning was 2.279 percent (X10) in early March. Sucrose then decreased when the temperature reached 46 ºF. Glucose concentrations were similar to those measured in bin 5, with high values of 0.010 percent observed in March and April. Glucose returned to acceptable levels by the end of the storage season, with a final concentration of 0.004 percent.

Chip color was initially very good, with no undesirable color reported until April. After this time, undesirable color rose to a high of 20.5% in June, but later returned to acceptable levels. Total defects were highest in late April, with chip samples in this time having total defects of 70.7 percent and 77.7 percent as scored by Techmark Inc. Towards the end of storage the percentage of total defects was very variable, ranging from the 9.8 percent to 81.2 percent. Similar to Bin 5, some of these defects could be caused by the elevated sucrose.

Figure 15. Bulk bin 6 first chip sample on 10/31/16, and last chip sample on 6/19/17.

Table 8. 2016-2017 PRESSURE BRUISE DATA Bulk Bin #5 and 6 Atlantic Y9 (Howard City, MI)								
Location[1]	Average Weight Loss (%)	Average Number of External Pressure Bruises Per Tuber[2]				Average % of Total Tuber Number		
		0	1	2	3+	Without Bruise	Bruised (No Color)	Bruised with Color[3]
14' Bin 5	3.34	7.00	11.67	6.00	0.33	28.0	72.0	0.0
8' Bin 5	4.16	4.00	6.33	12.67	2.67	16.0	85.3	1.3
3' Bin 5	5.46	1.33	8.67	7.67	7.33	5.3	94.7	0.0
OVERALL AVERAGES	**4.32**					**16.4**	**84.0**	**0.4**
14' Bin 6	3.65	5.33	10.00	6.00	3.67	21.3	77.3	1.3
8' Bin 6	4.37	1.67	4.00	8.67	10.67	6.7	92.0	1.3
3' Bin 6	6.58	0.67	0.67	9.67	14.00	2.7	93.3	4.0
OVERALL AVERAGES	**4.86**					**8.0**	**87.6**	**2.2**

[1] Feet above the bin floor.
[2] A Sample of 25 tubers randomly selected. Each tuber was first evaluated for the number of visual pressure bruises 0, 1, 2, 3+.
[3] A cut slice was removed just below the skin of each bruised area. If any flesh was darkened, it was scored as a tuber "with color".

Loaded	9/27/16	Pulp Temp. (at Filling)	59.0ºF		
Unloaded	6/12/17 (5) 6/7/17 (6)	Target Storage Temp.	44.0ºF (5) 46.0ºF (6)	End Temp.	52.0ºF

Manistee Storage Trial (Bins 8 and 9)

Manistee potatoes were grown in Stanton, MI, and planted on June 4, 2016. Vines were killed 102 days after planting on September 14, 2016, and the potatoes were harvested on October 19, 2016. The potatoes displayed characteristics of physiological and chemical maturity at harvest and had a specific gravity of 1.078 on September 12, 2016. Both bins 8 and 9 were loaded that same day with an initial pulp temperature of 60ºF. The bins were sprout treated on November 28, 2016. On June 5, 2017 the bins were unloaded at a final temperature of 52ºF. A storage protocol for Manistee at 50 ºF has previously been established, so these two bins observed tuber quality and marketability at lower temperatures. Both of these bins were processed by Shearer's Foods on June 6, 2017.

Results

Bulk Bin 8, Manistee, (GDD_{40} 3010, 48°F)

The initial sucrose concentration of Manistee in bin 8 was 0.817 percent (X10), but sucrose levels did not initially decrease during storage, instead fluctuating between 0.662 percent (X10) and a high of 1.049 percent (X10) between loading and mid-January. After this, sucrose concentrations gradually decreased, ending at 0.432 percent (X10) at bin unloading in June. Glucose was 0.002 percent at loading, reaching a high of 0.006 percent in February, shortly after the highest sucrose concentration. It was somewhat variable for the rest of the storage season, later decreasing to 0.003 percent in March, but rising to 0.007 percent in May.

Internal chip color was very good, with a high of 8.7 percent undesirable color reported in June. Total defects were also low, about 30 percent or lower except for two samples in November and February with defects measuring 40.6 percent and 46.4 percent, respectively.

Figure 16. Bulk bin 8 out of the field chip sample on 10/19/17, and last chip sample on 6/5/17.

Bulk Bin 9, Manistee, (GDD_{40} 3010, 46ºF)

Bulk bin 9 had high initial sucrose levels in storage, which remained high for most of the storage duration. Sucrose concentrations began to decrease in late March, ending at 0.430 percent (X10) at unloading. Glucose was somewhat variable, rising to 0.011 percent in January, fluctuating, and raising to 0.018 percent in late March. For the rest of the storage season glucose levels dropped, ending at 0.003 percent at unloading.

Chip color and quality decreased from loading to late January, with the highest percentage of internal color and total defects recorded on January 20, 2017 at 28.1 percent and 44.8 percent, respectively. During reconditioning chip color and defects improved, with a final chip sample displaying no undesirable color and 25.3 percent internal defects. Manistee potatoes kept at 48ºF appeared to have a longer marketing window than those kept at 46ºF as the 48ºF treatment had a lower level of total chip defects compared to the 46ºF treatment.

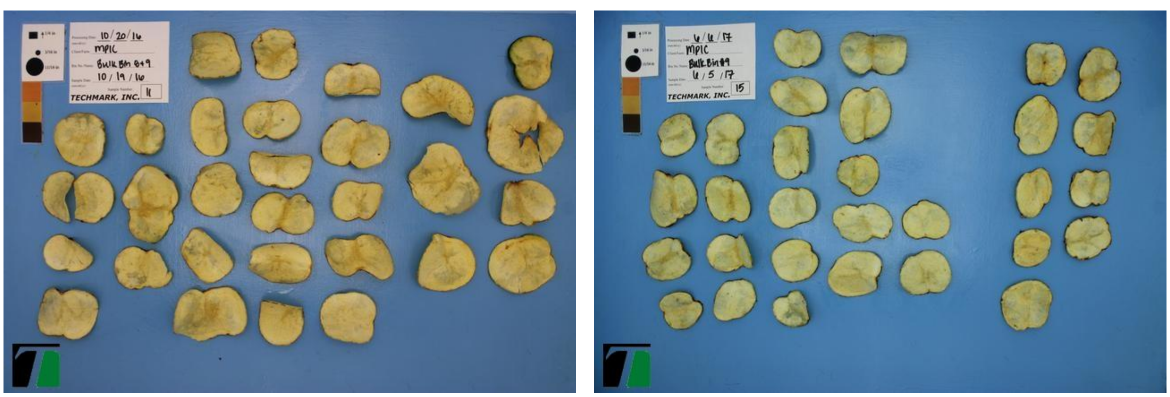

Figure 17. Bulk bin 9 out of the field chip sample on 10/19/17, and last chip sample on 6/5/17.

Table 9. 2016-2017 PRESSURE BRUISE DATA Bulk Bin #8 and 9 Manistee (Stanton, MI)								
Location[1]	Average Weight Loss (%)	Average Number of External Pressure Bruises Per Tuber[2]				Average % of Total Tuber Number		
		0	1	2	3+	Without Bruise	Bruised (No Color)	Bruised with Color[3]
14' Bin 8	0.18	12.33	11.67	1.33	0.00	49.3	52.0	0.0
8' Bin 8	1.60	13.67	6.33	1.33	0.00	54.7	45.3	0.0
3' Bin 8	4.28	11.00	8.67	5.33	0.33	44.0	54.7	1.3
OVERALL AVERAGES	**2.02**					**49.3**	**50.7**	**0.4**
14’ Bin 9	1.46	10.00	10.00	3.00	2.00	40.0	60.0	0.0
8’ Bin 9	2.29	5.67	12.67	5.33	1.67	22.7	77.3	1.3
3’ Bin 9	2.09	5.33	9.33	7.33	3.00	21.3	76.0	2.7
OVERALL AVERAGES	**1.95**					**28.0**	**71.1**	**1.3**

[1] Feet above the bin floor.
[2] A Sample of 25 tubers randomly selected. Each tuber was first evaluated for the number of visual pressure bruises 0, 1, 2, 3+.
[3] A cut slice was removed just below the skin of each bruised area. If any flesh was darkened, it was scored as a tuber "with color".

Loaded	10/19/16	Pulp Temp. (at Filling)	60.0ºF		
Unloaded	6/5/17	Target Storage Temp.	48.0ºF (8) 46.0ºF (9)	End Temp.	52.0ºF