Michigan State University
AgBioResearch

In Cooperation With
Michigan Potato Industry Commission

Michigan Potato Research Report
Volume 50
2018

Michigan Potato Industry Commission

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January 15, 2019

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 AgBioResearch and Michigan State University Extension. On behalf of all parties, we are proud to present you with the results of the 2018 potato research projects.

I hope that each of you see the value of your investment in these projects and can apply some of the results to strengthening your own operation.

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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2018 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2018 Potato Research Report contains reports of the many potato research projects conducted by Michigan State University (MSU) potato researchers at several locations. The 2018 report is the 50th 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 Trina Zavislan, MSU for organizing and compiling this final draft.

WEATHER

The overall 6-month average maximum and minimum temperatures during the 2018 growing season were slightly higher than the 15 year averages at 78°F and 53°F respectively (Table 1). May, June, and July were each at least 5 °F warmer than the 15 year average. Extreme heat events were slightly less than average in 2018 (Table 3) with 12 hours over 3 days in which temperatures exceeded 90 °F during the entire summer. Extreme high nighttime temperatures were slightly higher than average in 2018 compared to 2017 with 123 hours over 31 days exceeding 70 °F.

Rainfall for April through September was 22.76 inches, which was 5.49 inches above the 15-year average (Table 2). A total of 9.85 inches of irrigation water over 15 application timings was applied to Comden 1 between early June and mid-August. In general, May and August had more precipitation than average while July was a drier month.

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.
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
2018	**55**	**33**	**81**	**46**	**84**	**58**	**88**	**64**	**84**	**63**	**76**	**52**	**78**	**53**
15-Year Average	58	34	69	46	79	55	82	59	80	57	74	50	74	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
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	3.90	19.50
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
2018	**2.04**	**5.51**	**3.64**	**1.19**	**7.73**	**2.65**	**22.76**
15-Year Average	3.03	3.36	2.94	2.55	3.16	2.24	17.27

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
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
2018	**12**	**4**	**123**	**31**
Average	18	4	108	25

GROWING DEGREE DAYS

Table 4 summarizes the cumulative growing degree days (GDD) for 2018 while providing historical data from 2006-2018. 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 2018 was 4073 (Table 4), which is 285 GDD higher than the 13-year average of 3788.

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

Year	May	June	July	August	September
2006	532	1310	2298	3180	3707
2007	639	1503	2379	3277	3966
2008	447	1240	2147	2973	3596
2009	519	1264	2004	2800	3420
2010	610	1411	2424	3402	3979
2011	567	1354	2388	3270	3848
2012	652	1177	2280	3153	3762
2013	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
2018	**689**	**1487**	**2423**	**3373**	**4073**
Average	573	1343	2269	3146	3788

*2006-2018 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 2018 was Montcalm Research Center property in the field referred to as 'Comden 1.' This acreage was planted to oats in 2017 with crop residue disked into the soil. In the spring of 2018, 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 December 2017) was as follows:

	lbs/A			
pH	P	K	Ca	Mg
6.1	284 (142 ppm)	156 (78 ppm)	1022 (511 ppm)	180 (90 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 qts/A and Brawl II at 1.0 pts/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 2.0 qts/A, respectively.

Echo 720 (1.5 pts/A), Equus 720 (2.0 pts/A), Koverall (1.0 or 2.0 lbs/A), Manzate Pro Stick (2.0 lbs/A), and MH 30 (2.0 gal/A) fungicides were applied alone or in combination on twelve dates between June and mid-August.

Potato vines were desiccated with Reglone in early September at a rate of 2.0 pts/A.

2018 MSU POTATO BREEDING AND GENETICS RESEARCH REPORT
January 2019

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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 to meet Michigan's needs. Our program 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. This testing is crucial in determining the commercial potential of the lines. 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. We need to continue to combine these traits in long-term storage chip-processing lines. 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 are now 10 years down the road and we are benefiting from this technology as we can now query 35,000 SNPs for the same cost. 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. In 2019, we will test invertase silencing on a larger scale and learn more about the potential for drought tolerance and late blight resistance. Furthermore, PotatoesUSA 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. This national cooperative testing is key! We are leveraging the NCPT Fast Track program 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 as well a number of other traits in the future. We also have a USDA/AFRI diploid breeding grant to develop some foundational diploid breeding germplasm. In 2015, we were awarded the USAID Feed the Future 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, keep potato production profitable as well as reduce the reliance on chemical inputs such as insecticides, fungicides and sprout inhibitors, and improve overall agronomic performance through 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, we constructed a greenhouse to expand our breeding and certified minituber seed production with a hydroponic nutrient film technology (NFT) system. This greenhouse is at the MSU Crops facility on south campus. Also in 2016, we began to upgrade the grading line and this was completed with funding from MPIC and AgBioResearch. Variable speed drives control; a new lift; custom built barrel washer; grading table; and Kerian speed sizer are all part of the set up. Incorporation of bar-coded labels and scales synchronized to computer hot keys have improved the speed, accuracy and efficiency of the grading process. All entities of the potato group: Potato Breeding and Genetics; Potato Outreach Program; pathologists and soil fertility researchers have access to this new equipment. Thank you!

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 2018 field season, progeny from about 450 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 2018 harvest, over 1,000 selections were made from the 45,000 seedlings produced. In addition, about 700 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 2019 directly out of 45°F (7.2°C) and 50°F (10°C) storages. Atlantic, Pike (50°F chipper) and Snowden (45°F chipper) are chip-processed as check cultivars. Selections have been identified at each stage of the selection cycle that have desirable agronomic characteristics and chip-processing potential. At the 12-hill and 30-hill evaluation state, about 300 and 100 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. *Unfortunately, in 2018 we were unable to get the late blight infection to spread enough to collect useful data.* 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 as well as the traditional methods 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 1500 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 Mackinaw (MSX540-4) (scab, late blight and PVY resistant), MSV030-4 (scab resistant), MSV313-2 (scab resistant), Huron Chipper (MSW485-2) (late blight resistant), MSW075-2 (scab resistant), MSZ222-19 (scab resistant), MSZ242-13 (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 with broad adaptability. Manistee was licensed to Canada and Chile. Saginaw Chipper (MSR061-1) and Mackinaw (MSX540-4) are being tested in Australia.

Tablestock

Efforts have been made to identify lines with good appearance with an attractive skin finish, low internal defects, excellent culinary 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 types, red-skinned, and yellow-fleshed lines. We have also been selecting some pigmented skin and tuber flesh lines for specialty markets. There is also interest in additional specialty mini-potatoes for the "Tasteful selections" market. We have interest from some western specialty potato growers to test and commercialize 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 2018, while others were tested under replicated conditions at the Montcalm Research Center. Promising tablestock lines include MSV093-1 (yellow, scab resistant), MST252-1Y (scab resistant), MSV179-1 (scab resistant), MSW343-2R, MSX569-1R (scab resistant) and MSX324-1P (scab resistant). MSZ109-8PP and MSZ109-10PP (Blackberry) are purple-fleshed chippers with deep purple flesh, round shape and attractive skin as well as scab resistance. Jacqueline Lee (late blight resistant) was licensed to Australia and is being grown in Central America for its late blight resistance. Spartan Splash, Blackberry and our PVY resistant Red Marker #2 potato are being marketed in the specialty markets.

Disease and Insect Resistance Breeding

Scab: In 2018, we had two locations to evaluate scab resistance: a commercial field with a history of severe scab infection and a highly infected site at the Montcalm Research Center. The commercial site and the Montcalm Research Center both gave us very 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 MSZ-series selections from the commercial scab site. If you examine the Advanced Chip trial results, you will notice that almost all the lines are scab resistant. We need to continue in this direction of many selections with scab resistance so we can find the great scab resistant chipper. 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 check plots (Snowden and Atlantic) were scored as susceptible.

Based upon these results, common scab resistance is strong in the breeding program. We lead the nation in scab resistant lines as observed in the national NCPT scab disease trials. 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 on-farm is accelerating our ability to select for increased scab resistant varieties. MSZ219-1, MSZ219-13, MSZ219-14, MSZ022-07, MSZ222-19 and MSZ242-13 are some of the first scab resistant chippers to advance through this effort.

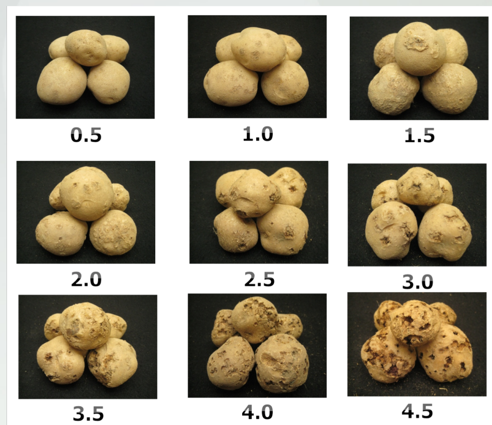
Fig. 1. Scab Disease Nursery Ratings from MRC trials

MICHIGAN STATE UNIVERSITY

Breeding for Scab Resistance

	Scab Disease Rating (0-5)									
Trial	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**Total**
Variety Trial	1	19	48	55	50	28	17	5	1	224
Early Generation	40	31	37	46	18	23	5	5	0	205
Diploid	39	38	38	58	21	7	3	2	0	206

Reference Variety	Scab Rating
Pike	1.8
Lamoka	2.0
Snowden	3.0
Atlantic	3.0



Late Blight: One of our core objectives 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 2018, we conducted late blight trials at the MSU campus. We inoculated with the US23 genotype but lacked good disease progression due to the 2018 climate. We are not reporting late blight trial results this year. We did conduct detached leaf bioassays in 2018 to study late blight resistance in a mapping study. US23 gave us good infection in the detached leaf tests, so we know that our cultures are virulent. We will continue with late blight trials in 2019 on the MSU campus.

PVY: We have focused on incorporating PVY resistance in our germplasm for years, with an increased emphasis in recent years to increase the frequency of PVY resistance in our advanced selections. We are using PCR-based DNA markers to select potatoes resistant to PVY. The gene is located on Chromosome 11. In 2013, we generated 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. As a result of this work, Mackinaw has PVY resistance as well as MSZ219-1, -13 and -14 (in addition to scab and late blight resistances). More PVY resistant advanced selections are in the queue.

Fig. 2 PVY resistant selections in the breeding program

Year	Family	PVY Resistance
YR0	MSGG	332 Families
YR1	MSFF	535 Selections to DNA screen
YR2	MSEE	473 Selections
YR3	MSDD	36 Selections
YR4	MSCC	11 Selections
YR5	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.

Mackinaw (MSX540-4)

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*).

Huron Chipper (MSW485-2)

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*).

Blackberry
(MSZ109-10PP)

Parentage: COMN07-W112BG1 x MSU200-5PP
Developers: Michigan State University and the MSU AgBioResearch
Plant Variety Protection: To Be Applied For.

Strengths: Blackberry is a tablestock variety with unique purple skin and a deep purple flesh. The tubers have an attractive, uniform, round shape and a purple flesh with common scab resistance and low incidence of internal defects. Yield can be high under irrigated conditions. Blackberry will also chip-process out of the field.

Incentives for production: The unique purple skin and purple flesh of the tubers of Blackberry offer a unique potato that could lend itself to the specialty variety market, such as gourmet restaurants and food stores, as well as farm and road-side markets. The primary market for this clone will be farm market and direct retail sale growers, and home gardeners. This variety is also used as a gourmet chip processing variety.

Morphological Characteristics:
Plant: Full-sized vine, semi-erect with a balance between stems and foliage visible, and flowers.
Tubers: Round tubers with a smooth skin and unique purple skin and purple flesh color. Tubers have a deep purple flesh with a low incidence of internal defects.

Agronomic Characteristics:
Maturity: Mid-season.
Tubers: Round tubers with unique purple skin and deep purple flesh.
Yield: Average to above average yield.
Specific Gravity: Averages 1.070 in Michigan.
Culinary Quality: Gourmet specialty with deep purple flesh and also chip-processes.
Foliage: Full-sized, semi-erect vine.
Diseases: Good common scab resistance.

Application of Molecular Markers in MSU Potato Breeding

With the development of molecular markers for potato breeding, marker-assisted selection has been incorporated into our routine breeding practice and greatly facilitates the selection process. Some of the main markers that are used at MSU include: *RYSC3* and M6, *Potato virus Y* (PVY) resistance markers; *RxSP*, a *Potato virus X* (PVX) resistance marker; *TG689*, a Golden Nematode resistance marker; RB and R8, Late Blight resistance markers. PVY markers have been the most frequently used tools to assist selection in our program due to the importance of PVY resistance. According to the pedigrees, selections from our single-hill trial (1st year of field selection) are screened for PVY markers every year. This allowed for a prioritization of the space in the field, and for earlier, more informed decisions in variety selection.

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 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. We are now bringing in late blight resistance genes from germplasm from Europe and China.

Germplasm Enhancement

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 analogous to what the corn breeders release.

Decoding *S. chacoense*-derived Colorado potato beetle resistance

Introgression of Colorado potato beetle resistance from *S. chacoense*-derived diploid recombinant inbred lines into cultivated backgrounds is being conducted through GREEEN funding. Subsequent marker assisted selection will yield diploid breeding lines with beetle resistance and desirable tuber traits. The spatio-temporal durability of this glycoalkaloid-based host plant resistance will be assessed using Colorado potato beetle populations from potato growing regions across the nation and examining 10 successive generations of beetles grown on host plant resistant material. Furthermore, the development of cross-resistance by beetles grown on host plant resistant material to commercial insecticides will be examined to inform the most sustainable deployment of this germplasm.

Overcoming self-incompatibility in diploid potato using CRISPR-Cas9

The aim of this project was to generate a targeted knock-out (KO) of the *S-RNase* gene, involved in gametophytic self-incompatibility in diploid potatoes, using CRISPR/Cas9 technology in an effort to avoid self-pollen degradation. We identified *S-RNase* alleles with flower-specific expression in two diploid self-incompatible lines using genome resequencing data. *S-RNase* gene mapped to chromosome 1 within a low recombination region. *S-RNase* KO lines were obtained causing premature stop codons. Fruits were set in selected KO and produced viable T1 seeds, and a Cas9-free KO line. Our results suggest that creating *S-RNase* KO can contribute to generation of self-compatible lines as a first step for the generation of commercial diploid cultivars.

Gene editing in diploid potato

MSU's breeding program has developed diploid germplasm with important agronomic qualities. These lines can be further characterized on traits for the use of gene editing. The first objective of this project is to characterize the MSU diploid germplasm for important molecular and morphological traits such as regeneration capability. The second major objective is to use gene editing, namely, CRISPR-Cas9 to knockout vacuolar invertase (*VInv*) in select diploid lines. The overall goal is to further advance the diploid breeding program by introducing economically important traits and proving the utility of gene editing in potato.

Dihaploid Potato Production at Michigan State University

The benefits of developing a broad germplasm of dihaploid potatoes brings the industry ever-closer to the expansive changes that would come with diploid potato breeding. Many of the challenges associated with tetraploid potatoes would be greatly reduced if the potato had a lower, and therefore less complicated, ploidy. Our goal is to develop a broad-based dihaploid germplasm that can be used in diploid potato breeding. We started by crossing successful varieties and advanced breeding lines from MSU tetraploid germplasm with a haploid inducer, *S. phureja* IVP 101. Tetraploid parent lines were selected based on traits such as high yield, disease resistance, and good chip quality, among others. Resulting seeds were inspected for a purple embryo spot and grown in tissue culture before transplanting in the greenhouse. Chloroplast numbers in guard cells were collected to determine ploidy level. Plants that we determined to be diploid were also SNP genotyped with the Infinium 22K Potato SNP array for ploidy confirmation. These dihaploids were then tested for disease resistance markers: RYSC3+ (Potato Virus Y extreme resistance), GN (Golden Nematode) resistance, and PVX resistance. Those with a Tollocan lineage were also tested for presence of R8 late blight resistance via a SNP KASP assay. Confirmed dihaploids were crossed with a diploid self-compatible inbred line of *S. chacoense*, M6 to introgress self-compatibility. Of the hundreds of seeds produced in the past 5 years from these diphaploid crosses with 18 breeding lines or varieties, about 80 progeny have been confirmed as diploid (2x). These dihaploids are the foundation of our diploid breeding program for round white potatoes for the chip and table markets.

Introgressing Self-compatibility to *Solanum tuberosum* Dihaploids for Diploid Variety Development

Dihaploids of cultivated potato (*Solanum tuberosum* L.) have been produced for over 50 years to reduce the breeding and genetic challenges of autopolyploidy. Most dihaploids are male sterile (MS) that reduces the benefit of lower ploidy level of cultivated tetraploid potato. In this study, we used three self-compatibility (SC) donors to introgress SC into a wide range of dihaploid germplasm through a series of crosses to dihaploids which we refer to as *S. tuberosum* backcrossing. The SC increased from 11% in the F_1 generation to 33% in the BC_2 generations. Over 6,000 genome-wide SNPs were used to characterize the germplasm diversity, heterozygosity, and structure in two backcrossing generations. The BC_2 generation was significantly improved regarding maturity, scab resistance, average tuber number, however, the yield in BC_2 was not greater than the F_1 and BC_1 generations.

Certified NFT Minituber Production at Michigan State University

For two years, the MSU Potato Breeding program has operated a certified NFT minituber production greenhouse. The ability to produce certified seed allows faster introduction of early generation material to the potato industry with commercial certified seed growers. It also helps position the program for participation in international trials, since the minitubers meet Phytosanitary requirements. We offer this service of small volume certified seed minituber production to other breeders and industry partners.

Integration of Genetic Engineering with Potato Breeding

MSU conducts genetic engineering research to introgress and test economically important traits into potato. We have a USAID-funded project to create and commercialize 3-R-gene potato varieties in Bangladesh and Indonesia. This project is a partnership with Simplot Plant Sciences. Simplot has been creating the plants for the target countries. Greenhouse trials show that a high level of resistance to late blight has been achieved in events that have no backbone and are single inserts. Trials are planned for the fall of 2019.

Furthermore, 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 and evaluated many lines with different genes for water use efficiency. The XERICO gene is showing the most promise. In 2018, we conducted a preliminary trial at MRC with tissue culture transplants of Ranger Russet events. These results are indicating that we are not seeing a yield hit from the XERICO gene. The

XERICO events also had a higher specific gravity than Ranger Russet. Meanwhile, the greenhouse experiments are showing an ability to refrain from wilting under sub-optimal soil water levels. In 2019, we will have a seed-tuber based field trial at MRC. 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 from 2016-2018. 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 conduct a larger block planting in 2019 to look more closely at this line under commercial setting.

Chipped directly after 3 months at 40F

Funding: Fed. Grant/MPIC/Potatoes USA

2018 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 2018, 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 (MSU Campus Plant Pathology Farm). 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 Matthew Klein and the MSU Potato Breeding Team (especially M. Alsahlany, F. Enciso, N. Kirkwyland, Lea Brunet and Oscar Regalia) 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 5 years. Oats were grown in 2017 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.

2018 was the eighth 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 Wisconsin.

In each of these trials, the yield was graded into four size classes using the new grading line, 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 345°F (174°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 seven years now. The 2018 late blight trial was conducted at the MSU campus Plant Pathology Farm. The simulated blackspot bruise (from 50°F tuber temperature) results for average spots per tuber have also been incorporated into the summary sheets.

RESULTS

A. Advanced Chip-Processing Trials (Tables 1 and 2)

A summary of the 24 entries evaluated in the trial results is given in **Table 1**. Overall, the yields for the Advanced trial (142 days) were above average. The check varieties for this trial were Snowden and Atlantic. The highest yielding and most promising lines were Mackinaw, MSZ222-19, MSZ096-03, MSZ219-14, MSZ219-1, MSZ242-02, MSZ242-13, MSZ219-13 and MSZ246-1. Internal defects were minimal for 2018 except for Atlantic and MSZ219-14 which had about 25% hollow heart in the large tubers. Specific gravity was below average with a trial average of 1.077. Snowden and Atlantic had a specific gravity of 1.080 and 1.085, respectively. All chip-processing entries in the trial had excellent chip-processing quality out of the field, with an SFA score of 1.0. Almost all of the MSU breeding lines have good scab resistance. Nineteen MSU chipping lines were classified as having scab resistance scores better than Lamoka (see Table 1). Mackinaw (MSX540-4) has PVY and late blight resistance while MSZ219-13, MSZ219-1 and MSZ219-14 (all three are scab, PVY and late blight resistant).

Table 2 had 24 entries and focuses mostly on additional chip-processing lines. Lamoka and Pike were used as the check varieties. MSV313-2, MSX245-2Y, Huron Chipper, MSY156-2 and MSW044-1 were lines that were equivalent or better in yield than Lamoka. Scab resistance was also high in most of these chip-processing lines. NY152 (Niagara) had a high yield but specific gravity was only 1.075 while Lamoka was 1.078. MSW044-1 was noted to have 23% hollow heart in the large tubers.

Please note in these chip trials the blackspot bruise was abnormally high due to an overaggressive bruising procedure that was mistakenly followed.

B. North Central Regional Trial Entries (Table 3)

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-five entries were tested in Michigan in 2018. The results are presented in **Table 3**. The reference varieties for this trial were Red Norland, Yukon Gold and Russet Norkotah. The highest yielding lines in the trial were ND1243-1PY, MSU Red Marker #2, MSZ109-10PP (Blackberry) and MSZ109-8PP. The three MSU lines produce a high yield with no internal defects. The two PP lines are also scab resistant while Red Marker #2 has PVY resistance. Other MSU lines that looked promising were MSW316-3PY and MSZ107-06PP with a purple tie dye appearance in the tuber flesh.

C. Russet Trial (Table 4)

In 2018 24 lines were evaluated after 133 days. The results are summarized in **Table 4**. 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 Silverton Russet and Reveille Russet were the standouts for yield. In most cases specific gravity was low with average for the trial was 1.072. Hollow heart was prevalent in the 2018 trial despite not having a high percentage of oversize tubers in the trial. Bruise incidence was average a few lines stood out as blackspot susceptible (A08433-4VRRUS, CO05068-1RUS and W10612-8RUS. Scab resistance was common among the lines but susceptibility was observed in a number of the russet lines (see Table 4).

D. Adaptation Trial (Table 5)

The Adaptation Trial of the tablestock lines was harvested after 130 days and the results of 24 lines are summarized in **Table 5**. The many of the lines evaluated in the Adaptation Trial were tested in the Preliminary Trials the previous year. Three reference cultivars (Red Norland, Yukon Gold and Onaway) are reported in the tablestock trial. In general, the yields were above average and internal defects were low, but MSZ590-1 had 18% hollow heart incidence. The highest yielding lines were our PP lines (MSZ109-08PP, MSZ109-10PP and MSV443-1PP. Scab tolerance is becoming more prevalent among the advanced selections but the challenge remains to combine scab and late blight resistance together. Blackspot bruising was low for most lines.

E. Preliminary Trials (Tables 6, 7 and 8)

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 2018, there were 109 entries trialed in the three Preliminary trials.

The chip-processing Preliminary Trial (**Table 6**) had 47 entries and was harvested after 123 days. Many of the lines chip-processed well from the field but specific gravity values were acceptable with Snowden at 1.081. Internal quality was predominantly vascular discoloration and hollow heart. Promising MSU lines are MSZ269-01Y, MSAA076-6, MSZ194-2, MSZ120-4 and MSAA217-3 combining yield, specific gravity, scab resistance and chip quality. We continue to make progress selecting for chip-processing with scab resistance with 22 lines in the trial with scab ratings equal or lower than 1.8. We are also combing chip-processing quality and late blight resistance, but we did not collect late blight results in 2018 to validate the 2017 results. MSZ120-4 is also noted to have strong verticillium wilt resistance.

Table 7 summarizes 32 tablestock entries evaluated in the Preliminary Tablestock Trial. Reba and Yukon Gold were the check varieties. This tablestock trial was harvested and evaluated after 123 days. MSAA196-6, MSAA174-1, MSAA196-1 and MSX472-2 were the promising highest yielding lines. These lines combine high yield potential with scab resistance and good internal quality. Besides some vascular discoloration, other internal defects were minimal. The number of tablestock selections with scab resistance continue to increase. We are also selecting for smoother/brighter skin finish.

The interest in the specialty market continues to increase. In 2018, 30 entries were evaluated in a targeted Preliminary Pigmented Trial (**Table 8**), which was harvested at 123 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 MSAA183-2PY, MSAA161-PY, MSAA166-2P, MSZ436-2SPL and MSAA101-1RR. Scab resistance was noted in 15 of the entries.

F. Potato Common Scab Evaluation (Tables 9 and 10)

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 seven years. This location is being used for the early generation observational scab trial (205 lines) and the scab variety trial (224 lines) and diploid scab trial (206). In 2018, the scab infection was aggressive with the susceptible control having a high coverage of pitted scab.

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 2016-2018 scab ratings are based upon the Montcalm Research Center site. **Table 9** categorizes many of the varieties and advanced selections tested in 2018 over a three-year period. The varieties and breeding lines are placed into nine 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 9**). The table is sorted in ascending order by 2018 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 0.3 - 4.0 for the variety trial. A total of 83 lines, of the 224 tested, had a scab rating of 1.5 or lower in 2018. Most notable scab resistant MSU lines are found in the trial summaries **(Tables 1-8)**.

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 411 early generation selections and diploid selections that were evaluated, 161 had scab resistance (scab rating of ≤ 1.5) (**Table 10**).

H. Late Blight Trial

In 2018, the late blight trial was planted at the East Lansing campus Plant Pathology farm. 206 entries were planted in early June for late blight evaluation. These include lines tested in a replicated manner from the agronomic variety trial (144 lines) and 62 entries in the early generation observation plots. The trials were inoculated three times in August with the US-23 genotype of *P. infestans*. Late blight infection was identified in the plots one week after the first inoculation, however, disease progression was arrested due to the hot, dry weather. As a result, we did not collect data that could discriminate resistant from susceptible lines.

I. Blackspot Bruise Susceptibility (Table 11)

Evaluations of advanced seedlings and new varieties for their susceptibility to blackspot bruising are also important in the variety evaluation program. Based upon the results collected over the past years, the non-bruised check sample has been removed from our bruise assessment. A composite bruise sample of each line in the trials consisted of 25 tubers (a composite of 4 replications) from each line, collected at the time of grading. The 25 tuber sample was held in 50°F (10°C) storage overnight and then was placed in a hexagon plywood drum and tumbled 10 times to provide a simulated bruise. The samples were peeled in an abrasive peeler in October and individual tubers were assessed for the number of blackspot bruises on each potato. These data are shown in **Table 11**. The bruise data are represented in two ways: percentage of bruise free potatoes and average number of bruises per tuber. A high percentage of bruise-free potatoes is the desired goal; however, the numbers of blackspot bruises per potato is also important. Cultivars which show blackspot incidence greater than Atlantic are approaching the bruise-susceptible rating. In addition, the data is grouped by trial, since the bruise levels can vary between trials. In 2018, the bruise levels were average compared to previous years except the Advanced Chip trials because of the aggressive bruise protocol. 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 1-8**).

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 10 locations. Since the inception of the trial in 2010, over 900 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. 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. We are using the NCPT trials to more effectively identify promising new selections. These are MSW485-2, MSX540-4, MSZ219-13, MSZ219-14 and MSW075-1, MSW474-1, MSZ063-2 and MSZ242-13 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 2019.

Table 1

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADVANCED CHIP-PROCESSING TRIAL
MONTCALM RESEARCH CENTER
May 7 to September 26, 2018 (142 days)
DD Base 40°F 3429[7]

		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	PERCENT (%) TUBER QUALITY[4]						3-YR AVG US#1
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	BRUISE[6]	CWT/A
MSZ222-19	4	572	621	92	7	92	0	1	1.082	1.0	0.0	13	0	3	0	1.2	3.2	540
MSZ096-03	4	446	473	94	6	93	1	0	1.077	1.0	0.0	0	18	0	0	1.3	2.6	-
MSZ248-10	4	415	450	92	7	91	1	1	1.076	1.0	1.0	0	10	8	0	1.3	3.7	-
MSZ219-14	4	414	449	92	7	91	1	1	1.077	1.0	0.0	28	8	0	0	0.8	3.3	401
MSZ219-01	4	411	434	94	4	94	1	2	1.078	1.0	0.0	0	8	0	0	0.5	3.5	442
MSZ052-14	4	394	432	91	7	91	0	2	1.073	1.0	0.0	3	10	0	0	1.5	3.6	-
MSZ219-46	4	384	427	90	8	89	1	2	1.073	1.0	1.0	3	20	0	0	1.0	2.7	396*
MSZ242-07	4	380	405	94	4	91	3	2	1.088	1.0	0.0	0	0	0	0	1.5	3.2	337*
Manistee	3	369	405	91	8	90	1	1	1.078	1.0	0.0	3	7	0	0	2.2	2.4	382
Mackinaw (MSX540-4)	3	363	400	91	8	90	1	1	1.085	1.0	0.0	0	10	0	0	1.8	3.8	358
MSZ025-02	4	357	386	92	8	92	0	0	1.073	1.0	0.0	0	5	0	0	2.7	2.8	-
Atlantic	**4**	**356**	**379**	**94**	**3**	**94**	**0**	**3**	**1.085**	**1.0**	**0.0**	**25**	**10**	**3**	**0**	**3.0**	**4.3**	397
MSZ242-13	4	350	371	95	5	94	0	1	1.090	1.0	0.0	0	3	0	0	1.3	4.2	279
MSZ246-1	4	339	388	87	13	87	0	0	1.083	1.0	0.0	13	10	0	0	1.2	3.6	-
MSZ219-13	4	335	354	95	5	93	1	0	1.075	1.0	0.0	3	5	0	0	0.8	3.7	366*
Snowden	**4**	**320**	**362**	**88**	**12**	**88**	**0**	**0**	**1.080**	**1.0**	**0.0**	**3**	**48**	**0**	**0**	**3.0**	**4.4**	442
MSZ022-07	4	296	333	89	10	88	1	1	1.072	1.0	0.0	0	10	3	0	1.2	2.5	-
MSZ118-8	1	275	400	69	31	69	0	0	1.075	nd	nd	0	0	30	10	1.2	nd	-
MSZ242-09	4	271	315	86	9	86	0	5	1.083	1.0	0.0	0	10	13	0	0.7	4.3	366
MEAN		371	410						1.079							1.5	3.4	401
$HSD_{0.05}$		175	177						0.009									

* 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]BRUISE: Simulated blackspot bruise test, average number of spots per tuber.

Plant Date: 5/7/2018
Vine Kill: 9/6/2018
Days from planting to vine kill: 122
[7]Enviroweather: Entrican Station. Planting to vine kill

Table 2

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADVANCED LINES TRIAL
MONTCALM RESEARCH CENTER
May 7 to September 24, 2018 (140 days)
DD Base 40°F 3429[7]

		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	PERCENT (%) TUBER QUALITY[4]						3-YR AVG US#1
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	BRUISE[6]	CWT/A
MSV313-2	3	537	555	97	2	87	10	1	1.077	1.0	0.0	3	7	7	0	1.0	3.1	451
MSX245-2Y	4	504	529	95	5	94	2	0	1.081	1.0	3.0	0	20	10	0	2.0	3.1	-
MSX156-1Y	4	494	512	96	2	86	11	2	1.062	2.0	1.0	3	3	13	0	2.1	2.6	-
NY152	4	472	521	90	8	90	0	2	1.075	1.0	0.0	3	3	13	0	2.2	3.6	-
MSV093-1Y	4	457	484	94	4	93	2	1	1.066	-	-	0	10	0	0	1.7	1.6	-
Huron Chipper (MSW485-2)	4	445	488	91	8	91	0	0	1.083	1.0	1.0	0	13	5	0	1.7	2.2	444
MSY156-2	4	433	458	94	5	94	0	1	1.078	1.0	0.0	3	28	8	0	1.8	2.6	-
MSV498-1	4	402	430	93	5	93	0	1	1.072	1.0	0.0	10	30	3	0	1.8	3.9	353*
MSW075-1	4	392	445	87	12	87	0	0	1.074	1.0	0.0	0	15	3	0	2.0	3.3	380*
MSW353-3	2	369	387	96	1	88	8	3	1.072	-	-	0	50	0	0	1.2	nd	409*
MSV507-007	4	368	411	89	5	87	2	5	1.074	1.0	0.0	0	13	8	0	1.8	4.1	-
Lamoka	**4**	**363**	**397**	**91**	**6**	**91**	**0**	**3**	**1.078**	**1.5**	**0.0**	**0**	**25**	**3**	**0**	**2.0**	**3.2**	**363**
MSW044-01	4	354	425	82	15	81	1	3	1.080	1.0	0.0	23	3	5	0	1.7	3.9	395*
Pike	**4**	**308**	**340**	**90**	**8**	**90**	**0**	**1**	**1.079**	**1.0**	**1.0**	**0**	**48**	**3**	**0**	**1.8**	**1.7**	**309**
MSV358-3	4	289	321	90	10	90	0	1	1.078	1.0	0.0	3	5	0	0	1.7	1.6	344
MSX194-3	4	282	321	88	12	88	0	0	1.070	-	-	0	0	0	0	1.2	nd	-
MSU379-1	1	274	311	88	11	88	0	1	1.072	1.0	2.0	0	0	0	0	1.7	2.2	410*
MSW502-4	2	263	309	85	15	85	0	0	1.083	1.5	2.0	0	0	5	0	1.3	3.5	-
MSW064-1	1	229	238	96	2	96	0	2	1.081	1.0	0.0	0	40	10	0	2.0	3.0	284*
MSV235-2PY	4	169	287	57	42	57	0	0	1.070	-	-	0	30	3	0	2.8	2.4	-
MSW100-1	2	100	190	52	48	52	0	0	1.081	-	-	0	15	10	0	1.3	nd	-
MSZ109-05RR	4	24	117	21	79	21	0	1	1.061	-	-	0	0	5	0	0.5	1.4	-
MEAN		342	385						1.075							1.7	2.8	382
$HSD_{0.05}$		190	195						0.007									

* 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]BRUISE: Simulated blackspot bruise test, average number of spots per tuber.

Plant Date: 5/7/2018
Vine Kill: 9/6/2018
Days from planting to vine kill: 122
[7]Enviroweather: Entrican Station. Planting to vine kill

Table 3

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH CENTER
May 07 to September 10, 2018 (126 days)
DD Base 40°F 3236[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]						3-YR AVG US#1
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	Bruise[4]	CWT/A
Yellow Flesh and Pigmented																
ND1243-1PY	2	563	629	89	10	82	7	1	1.072	45	5	0	0	2.7	2.6	461*
MSU Red Marker #2	2	555	599	93	7	83	10	0	1.074	0	5	0	0	2.5	1.6	-
MSZ109-10PP	2	538	659	82	16	82	0	3	1.060	0	0	0	0	1.2	0.3	-
MSZ109-08PP	2	515	598	86	9	86	0	5	1.060	0	0	0	0	1.0	0.2	-
ND1232B-2RY	2	452	550	82	17	82	0	1	1.069	0	0	0	0	2.0	1.5	331*
Yukon Gold	**2**	**447**	**493**	**91**	**6**	**83**	**8**	**4**	**1.074**	**5**	**15**	**0**	**5**	**2.6**	**1.0**	**414**
AND00272-1R	2	379	452	84	15	82	2	2	1.060	0	5	0	0	-	0.6	301*
W13103-2Y	2	369	412	89	8	89	0	2	1.057	5	10	0	0	2.0	0.5	358*
ND1241-1Y	2	367	473	77	22	77	0	1	1.096	0	10	0	0	3.3	3.0	328*
QSNDSU07-04R	2	354	385	92	7	92	0	1	1.058	0	5	5	0	2.5	0.6	325*
MSZ107-06PP	2	330	420	78	20	78	0	3	1.069	0	10	0	0	2.0	0.4	-
MSW316-3PY	2	291	447	66	15	66	0	19	1.066	0	15	0	0	2.7	1.9	304
ND081571-2R	2	282	335	82	18	82	0	0	1.054	0	5	0	0	2.3	0.0	-
Red Norland	**2**	**279**	**328**	**85**	**14**	**85**	**0**	**0**	**1.055**	**0**	**0**	**0**	**0**	**1.3**	**0.4**	**308**
ND102663B-3R	2	277	396	68	29	68	0	2	1.061	0	0	0	0	1.8	0.1	-
MSQ558-2RR	2	271	362	75	23	75	0	2	1.066	0	0	0	0	-	2.2	-
MSR226-ARR	2	241	367	65	32	65	0	3	1.069	0	5	0	0	-	2.0	-
ND12128B-1R	2	141	261	52	46	52	0	3	1.066	0	5	0	0	2.8	0.8	-
ND113113B-2PSY	2	94	201	46	46	46	0	8	1.071	0	0	0	5	2.2	2.7	-
Russet																
W14176-5rus	2	392	494	79	8	75	4	13	1.085	0	25	0	0	1.5	3.0	-
W14176-14rus	2	341	401	85	15	85	0	0	1.084	0	5	0	0	1.2	1.0	-
W13027-46rus	2	299	339	88	8	50	38	4	1.069	10	5	0	0	1.5	1.3	-
W13008-1rus	2	270	297	91	7	66	25	2	1.067	0	5	0	0	1.8	0.9	347*
Russet Norkotah	**2**	**178**	**270**	**66**	**32**	**63**	**3**	**2**	**1.066**	**10**	**5**	**0**	**0**	**2.8**	**0.5**	**241**
W13015-17rus	2	115	213	53	47	53	0	0	1.073	0	5	0	0	1.7	1.1	-
MEAN		334	415						1.068					2.1	1.2	317
$HSD_{0.05}$		239	215						0.009							

* 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]BRUISE: Simulated blackspot bruise test, average number of spots per tuber.

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

Plant Date: 5/7/2018
Vine Kill: 8/31/2018
Days from planting to vine kill: 116

Table 4

RUSSET TRIAL
MONTCALM RESEARCH CENTER
May 07 to September 17, 2018 (133 days)
DD Base 40°F 3429[5]

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]	BRUISE[4]	3-YR AVG US#1 CWT/A
Silverton Russet	**4**	**444**	**492**	**90**	**8**	**90**	**0**	**3**	**1.065**	**20**	**8**	**0**	**0**	**1.2**	**0.4**	**416**
Reveille (ATX91137-1Rus)	4	414	457	90	7	90	0	3	1.069	0	5	0	0	2.0	1.1	387
A08433-4VRRUS	4	385	463	83	10	83	0	7	1.077	38	8	0	0	2.0	2.6	-
WAF10612-1RUS	4	379	473	80	14	80	1	6	1.074	13	5	0	0	3.3	2.0	-
Caribou (AF3362-1Rus)	4	345	383	90	5	90	0	5	1.072	0	13	3	0	1.0	1.1	380*
AF5406-7RUS	4	335	459	73	12	73	0	15	1.075	20	18	0	0	1.3	1.4	-
A071012-4BFRUS	4	316	389	81	13	81	0	5	1.086	40	8	0	0	2.8	3.2	-
Russet Norkotah	**4**	**304**	**379**	**80**	**14**	**80**	**0**	**6**	**1.069**	**28**	**13**	**0**	**0**	**2.8**	**1.4**	**358**
Mountain Gem (A03158-2TERUS)	4	303	375	79	9	78	1	12	1.069	63	27	0	0	0.8	2.0	344*
AF5091-8RUS	4	300	359	83	11	83	0	6	1.065	0	10	0	0	2.5	1.4	349
CO05068-1RUS	4	293	417	70	25	70	0	5	1.088	58	13	58	0	1.7	3.8	-
A07061-6RUS	3	287	350	83	15	83	0	3	1.071	0	3	0	0	2.5	1.4	385*
AF5179-4RUS	4	284	354	80	9	80	0	10	1.084	5	20	0	0	4.0	1.8	370*
W10612-8RUS	4	276	306	90	7	90	0	3	1.073	3	8	0	0	2.0	3.7	-
A06021-1TRUS	4	264	321	82	15	82	0	3	1.077	5	8	0	0	1.3	1.9	251*
Goldrush Russet	**4**	**254**	**319**	**80**	**15**	**80**	**0**	**5**	**1.062**	**0**	**23**	**0**	**0**	**0.7**	**1.4**	**328***
TX08352-5Rus (Vanguard)	4	230	265	86	11	86	0	3	1.060	0	5	0	0	1.8	1.6	238
CW08071-2RUS	4	222	260	85	8	85	1	7	1.073	5	10	0	0	2.0	2.5	-
W10594-16RUS	4	211	284	74	25	74	0	2	1.076	3	0	0	0	3.2	0.6	-
CO07049-1RUS	4	202	317	62	35	62	0	3	1.068	0	5	0	0	1.7	1.0	-
AF5312-1RUS	4	196	281	70	22	70	0	8	1.066	5	5	0	0	0.8	2.2	273*
CO09036-2RUS	4	153	271	56	40	56	0	4	1.073	0	20	0	0	0.8	1.3	-
CO07015-4RUS	4	122	222	53	45	53	0	2	1.067	0	0	0	0	1.2	0.8	-
MEAN		283	356						1.072					1.9	1.8	349
$HSD_{0.05}$		150	151						0.007							

* 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]BRUISE: Simulated blackspot bruise test average number of spots per tuber.
[5]Enviroweather: Entrican Station. Planting to vine kill

Plant Date: 5/7/18
Vine Kill: 9/6/18
Days from planting to vine kill: 122

Table 5

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH CENTER
May 07 to September 14, 2018 (130 days)
DD Base 40°F 3429[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	BRUISE[4]
MSZ109-08PP	4	463	531	87	12	87	0	1	1.058	0	0	0	0	1.0	0.4
MSV443-1PP	2	460	506	91	9	91	0	0	1.059	0	0	0	0	1.5	nd
MSZ109-10PP	4	454	567	80	18	80	0	2	1.061	0	0	0	0	1.2	0.5
MSZ428-1PP	4	398	448	89	8	88	0	3	1.066	0	0	0	0	1.0	0.5
MSV179-1	4	378	390	97	3	90	7	1	1.060	0	3	0	0	1.5	1.0
MSZ598-2	4	375	403	93	6	92	1	1	1.065	0	13	5	3	1.5	2.4
Onaway	**4**	**366**	**414**	**88**	**8**	**87**	**1**	**4**	**1.058**	**0**	**13**	**0**	**0**	**2.5**	**1.7**
MSX398-2	4	352	370	95	4	94	1	1	1.077	0	8	0	0	1.8	1.0
MSY111-01	2	334	373	89	10	88	1	1	1.065	0	10	10	0	1.3	nd
MSZ407-2Y	4	332	358	92	6	91	1	2	1.075	0	13	0	0	1.2	1.7
MSZ413-6P	4	329	407	81	19	81	0	0	1.067	0	15	0	0	1.3	0.6
MSW148-1P	1	327	408	80	18	80	0	1	1.079	0	0	0	0	2.7	nd
MSX354-06Y	2	325	339	95	5	88	8	0	1.077	0	0	0	0	2.2	nd
MSV111-2	4	310	385	81	18	81	0	1	1.069	0	8	3	3	1.8	0.5
MSX497-06	4	305	316	96	3	95	1	0	1.063	0	3	0	0	3.0	1.5
MSZ590-1	4	294	353	83	16	83	0	1	1.065	18	13	3	3	1.0	1.5
MSW316-03PY	3	293	418	70	19	70	0	11	1.069	0	7	0	0	2.7	0.6
MSZ107-06PP	4	293	452	64	35	64	0	0	1.072	3	0	0	0	2.0	0.6
MSW343-2R	2	289	322	89	10	88	1	0	1.049	0	10	0	0	2.2	nd
MST252-1Y	4	286	344	83	15	83	0	2	1.064	0	13	0	0	1.5	1.2
Red Norland	**4**	**284**	**314**	**90**	**9**	**90**	**0**	**0**	**1.055**	**0**	**23**	**0**	**0**	**1.3**	**0.1**
MSX324-1P	4	269	326	82	16	82	0	2	1.076	0	13	5	0	0.8	1.9
Yukon Gold	**3**	**177**	**208**	**85**	**8**	**85**	**0**	**7**	**1.066**	**3**	**27**	**0**	**0**	**2.6**	**0.6**
MEAN		335	389						1.066					1.7	1.0
$HSD_{0.05}$		147	148						0.011						

[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]BRUISE: Simulated blackspot bruise test average number of spots per tuber.
[5]Enviroweather: Entrican Station. Planting to vine kill

Plant Date: 5/7/2018
Vine Kill: 9/6/2018
Days from planting to vine kill: 122

Table 6

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH CENTER
May 7 to September 10, 2018 (126 days)
DD Base 40°F 3236[7]

		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	PERCENT (%) TUBER QUALITY[4]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	BRUISE[6]
BNC182-5	2	605	631	96	4	84	11	0	1.081	1.0	0.0	10	20	0	0	2.7	4.0
MSZ269-01Y	2	555	590	94	6	76	18	0	1.078	1.5	3.0	0	5	5	0	1.0	nd
MSAA076-6	2	552	602	91	7	88	3	1	1.086	1.0	1.0	0	5	15	0	1.3	3.8
AC03452-2W	2	508	562	90	8	86	5	1	1.067	1.0	0.0	5	0	0	0	2.8	0.8
MSZ194-2	2	501	530	94	4	82	13	2	1.078	1.0	3.0	0	0	0	0	2.3	2.9
CO02321-4W	2	493	537	92	7	83	9	1	1.080	1.0	1.0	0	15	0	0	2.8	1.9
MSAA725-3	2	493	537	92	3	73	19	5	1.069	-	-	0	25	0	0	1.8	0.9
MSZ120-4	2	489	543	90	9	85	5	1	1.079	1.0	3.0	0	0	0	0	1.7	3.5
MSZ248-02	2	486	507	96	3	83	12	2	1.067	1.5	2.0	0	10	20	0	2.0	4.2
B2904-2	2	483	512	95	4	84	10	2	1.080	1.0	2.0	0	15	0	0	3.0	1.6
MSAA217-3	2	466	475	98	2	70	28	0	1.089	1.0	0.0	35	5	0	0	1.7	2.6
Snowden	**2**	**442**	**480**	**92**	**7**	**85**	**7**	**1**	**1.081**	**1.0**	**2.0**	**25**	**20**	**0**	**0**	**3.0**	**3.3**
MSZ268-1Y	2	441	482	91	7	75	16	1	1.074	1.5	3.0	10	15	5	0	1.8	3.7
W9968-5	2	435	481	91	8	83	7	2	1.087	1.0	1.0	5	15	10	0	2.0	2.4
MSZ144-4Y	2	432	494	87	11	80	7	1	1.068	-	-	35	0	0	5	2.2	1.2
B2869-29	2	429	481	88	11	82	6	1	1.087	1.5	1.0	0	15	0	0	3.3	3.3
MSAA085-1	2	427	451	94	5	79	15	0	1.076	1.0	1.0	10	10	0	0	1.8	3.2
MSZ200-6	2	425	489	87	12	85	2	1	1.072	-	-	0	20	0	0	1.7	3.2
MSAA240-6	2	424	478	89	8	70	19	3	1.082	1.0	1.0	10	20	0	5	2.7	2.1
MSX177-7Y	2	423	501	85	6	78	7	9	1.076	1.0	0.0	0	0	0	0	0.5	2.4
MSX225-1	2	405	446	91	9	86	5	1	1.086	1.0	3.0	20	5	0	5	1.5	1.7
CO02033-1W	2	395	459	86	14	82	4	0	1.083	1.0	0.0	25	15	0	5	3.3	2.9
MSAA228-1	2	391	422	93	5	78	15	2	1.074	-	-	5	5	0	0	2.0	0.5
MSAA570-3	2	390	427	91	3	65	26	5	1.080	1.0	0.0	5	5	0	0	2.2	4.0
MSAA208-2	2	387	425	91	9	88	3	0	1.085	-	-	0	20	10	0	2.7	1.0
MSZ102-5	2	384	420	92	6	72	20	3	1.076	1.0	0.0	0	0	0	0	0.8	3.4
MSZ020-08	2	382	425	90	8	81	8	2	1.073	1.0	0.0	0	0	0	5	1.3	2.0
MSZ242-03	2	374	427	88	10	82	5	2	1.076	1.0	2.0	0	0	0	0	0.8	1.5
MSZ022-19	2	363	406	89	8	73	17	2	1.074	1.0	0.0	5	0	10	5	1.3	2.7
MSAA037-1	1	362	446	81	18	81	0	1	1.084	-	-	0	10	0	0	3.5	2.0
MSAA266-1	2	361	379	95	2	63	32	3	1.071	1.0	1.0	10	5	0	0	2.0	1.7
MSAA244-1	2	359	389	92	6	85	7	1	1.063	1.0	0.0	0	0	0	0	1.3	1.0
Pike	**2**	**356**	**384**	**93**	**7**	**84**	**9**	**0**	**1.080**	**1.0**	**2.0**	**15**	**10**	**5**	**0**	**1.8**	**2.1**

Table 6

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH CENTER
May 7 to September 10, 2018 (126 days)
DD Base 40°F 3236[7]

		CWT/A		PERCENT OF TOTAL[1]						CHIP	OTF	PERCENT (%) TUBER QUALITY[4]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	SED[3]	HH	VD	IBS	BC	SCAB[5]	BRUISE[6]
MSAA232-4	2	337	364	93	6	82	10	2	1.077	1.0	0.0	15	5	0	0	2.2	2.6
MSZ092-02	2	328	352	92	6	78	14	2	1.073	1.0	1.0	0	0	0	0	1.8	1.3
MSAA571-3Y	2	316	349	90	9	80	11	1	1.074	1.0	0.0	0	10	0	0	2.2	3.4
MSAA061-7	2	314	385	81	18	80	1	1	1.080	1.0	0.0	0	5	5	0	1.2	2.2
BNC311-4	2	307	376	82	9	77	5	9	1.074	1.0	2.0	0	5	0	0	3.0	2.4
MSAA353-1	2	294	314	94	6	77	17	0	1.077	-	-	20	5	0	0	1.7	4.1
MSAA678-1	2	287	321	89	7	75	15	4	1.080	1.0	1.0	5	15	0	0	2.2	3.8
MSZ100-03	2	260	297	88	6	83	4	6	1.067	-	-	0	0	0	0	3.2	1.1
MSW537-6	2	240	261	91	9	90	1	0	1.088	1.0	1.0	0	10	0	0	1.7	2.8
AC00206-2W	2	232	288	81	18	77	4	1	1.069	1.0	0.0	5	5	0	0	3.2	0.8
AC05153-1W	2	223	320	69	29	69	0	3	1.071	1.0	1.0	0	10	0	0	3.7	1.0
MSZ159-3	1	209	333	63	31	63	0	7	1.078	-	-	10	10	0	0	2.3	2.0
MSZ022-14	2	204	219	93	7	76	16	0	1.065	1.0	3.0	0	5	0	0	0.8	2.3
MSZ269-18	2	162	216	75	25	75	0	0	1.072	1.5	0.0	0	5	0	0	1.0	2.2
MEAN		386	430						1.077							2.1	2.4
$HSD_{0.05}$		260	263						0.009								

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

Plant Date: 5/7/2018
Vine Kill: 8/31/2018
Days from planting to vine kill: 116

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

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH CENTER
May 7 to September 7, 2018 (123 days)
DD Base 40°F 3236[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	BRUISE[4]
MSZ510-4	2	665	691	96	2	81	15	2	1.062	0	15	0	0.0	2.3	1.5
MSAA196-6	2	484	546	89	9	88	1	2	1.061	0	40	0	0.0	2.0	1.2
MSAA174-1	2	478	501	96	4	96	0	1	1.058	0	20	15	0.0	1.5	1.4
Reba	**2**	**442**	**455**	**97**	**3**	**96**	**1**	**0**	**1.069**	**15**	**0**	**5**	**0.0**	**2.5**	**2.9**
AF4138-8	2	399	431	93	7	93	0	0	1.059	0	15	5	0.0	1.3	2.0
Orlena	2	395	466	85	9	85	0	7	1.053	0	35	5	0.0	2.5	1.8
Soraya	2	386	502	77	10	77	0	14	1.059	0	25	10	0.0	1.3	0.7
MSAA196-1	2	379	473	80	16	80	0	4	1.060	0	25	0	0.0	1.5	1.0
W9576-11Y	2	377	445	84	16	84	0	0	1.058	0	25	5	0.0	1.3	0.9
AF5280-5	2	372	411	90	9	90	1	1	1.058	0	30	0	0.0	1.8	0.3
Laperla	2	364	416	87	9	86	1	4	1.050	0	20	0	0.0	3.3	1.3
MSX472-2	2	363	419	87	13	87	0	0	1.068	10	5	10	0.0	1.3	2.0
Yukon Gold	**2**	**360**	**396**	**91**	**8**	**89**	**2**	**2**	**1.075**	**5**	**35**	**0**	**0.0**	**2.6**	**1.6**
Alegria	2	349	443	79	11	79	0	11	1.070	0	20	0	0.0	2.3	2.8
Wendy	2	340	459	74	23	74	0	3	1.062	0	5	0	0.0	3.5	1.3
MSX269-4Y	1	320	370	87	8	87	0	6	1.066	0	10	0	0.0	2.2	nd
MSL211-3	2	314	353	89	10	89	0	1	1.064	0	10	0	0.0	2.0	1.3
NY149	2	311	373	83	14	83	0	3	1.071	10	35	10	0.0	1.8	0.7
MSX526-02Y	2	298	350	85	14	85	0	1	1.066	0	10	5	0.0	2.7	1.1
MSW119-2	2	290	341	85	14	85	0	1	1.070	0	15	10	0.0	1.3	2.0
MSAA168-8	2	288	321	90	9	90	0	2	1.073	0	15	10	0.0	1.5	2.5
Queen Anne	2	285	349	81	18	81	0	0	1.057	0	10	0	0.0	1.7	0.8
MSZ615-2	2	273	286	95	5	95	0	0	1.065	0	5	0	0.0	1.7	2.0
MSZ709-04	2	258	319	81	15	81	0	4	1.079	5	5	0	0.0	1.5	2.0
Bonnata	2	244	343	71	16	71	0	14	1.065	0	30	5	0.0	2.8	1.0
MSX293-1Y	2	236	275	86	12	86	0	2	1.074	0	20	5	0.0	2.2	1.5
MSAA168-3	2	232	303	77	23	77	0	0	1.070	0	0	5	0.0	2.2	2.8
MSZ513-2	2	231	257	90	9	88	2	1	1.066	0	40	10	0.0	1.3	2.1

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH CENTER
May 7 to September 7, 2018 (123 days)
DD Base 40°F 3236[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	BRUISE[4]
MSV177-1	2	212	264	80	8	80	0	12	1.079	5	0	0	0.0	1.0	0.8
MSZ706-1	2	198	337	60	29	60	0	11	1.078	0	5	0	0.0	3.5	2.4
MSAA131-2	1	132	177	74	23	74	0	3	1.062	10	30	0	0.0	2.3	nd
Jazzy	2	54	291	19	61	19	0	20	1.060	0	20	5	0.0	2.7	0.9
MEAN		323	386						1.065					2.0	1.6
$HSD_{0.05}$		219	229						0.012						

[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]BRUISE: Simulated blackspot bruise test average number of spots per tuber.
[5]Enviroweather: Entrican Station. Planting to vine kill

Plant Date: 5/7/2018
Vine Kill: 8/31/2018
Days from planting to vine kill: 116

Table 8

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, PIGMENTED LINES
MONTCALM RESEARCH CENTER
May 7 to September 7, 2018 (123 days)
DD Base 40°F 3236[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	Bruise[4]
MSAA183-2PY	2	509	563	90	9	86	4	1	1.062	0	15	0	0	1.7	1.6
W8405-1R	2	456	520	88	10	88	0	2	1.060	0	5	0	0	2.7	2.3
MSS514-1PP	1	445	538	83	9	83	0	8	1.060	0	0	0	0	2.0	0.9
MSAA157-2PY	2	438	525	83	14	81	3	2	1.067	30	5	0	0	2.3	2.0
MSAA161-1PY	2	434	505	86	12	86	0	2	1.076	0	15	0	0	1.7	1.6
MSAA166-2P	2	431	520	83	15	83	0	2	1.068	0	0	0	0	1.5	1.6
MSZ436-2SPL	2	418	458	91	5	83	8	3	1.053	0	5	5	0	1.8	0.3
AF4831-2R	2	414	497	83	17	83	0	0	1.073	0	5	0	0	3.0	0.9
Cerata	2	411	465	88	7	88	0	5	1.061	0	10	0	0	2.2	0.3
MSZ443-1PP	2	411	486	84	13	84	0	2	1.061	5	0	0	0	2.2	0.8
MSAA101-1RR	2	384	516	74	23	74	0	3	1.076	0	10	0	0	0.5	2.3
MSAA127-7PP	2	374	455	82	17	82	0	1	1.055	0	0	0	0	2.2	0.7
MSZ427-1R	2	373	454	81	16	81	0	3	1.058	0	10	0	0	1.2	0.7
MSAA161-4RY	2	351	431	81	14	71	10	5	1.068	0	0	0	10	0.8	1.6
MSAA127-1PP	2	349	382	91	8	91	0	0	1.051	0	0	0	0	2.3	1.3
MSZ427-3R	2	348	434	80	19	80	0	1	1.051	0	15	0	0	2.0	1.3
MSW476-4R	2	336	395	85	10	84	1	5	1.072	5	30	0	0	2.5	0.6
CO98012-5R	2	311	389	81	19	81	0	1	1.065	5	0	0	0	3.3	1.1
MSX569-1R	2	308	376	81	18	81	0	1	1.052	0	10	0	5	1.3	0.6
W8890-1R	2	270	346	77	22	77	0	1	1.056	0	20	0	0	1.7	0.5
MSX324-2R	2	268	315	85	14	85	0	1	1.068	0	5	0	0	2.0	1.6
MSZ107-01PP	2	266	414	64	33	64	0	3	1.070	0	0	0	0	1.0	0.3
MSAA182-3R	2	247	391	63	36	63	0	2	1.075	0	5	0	0	1.5	0.4
AF5245-1P	2	245	365	67	32	67	0	1	1.073	10	5	0	0	1.5	1.2
Mystery Splash	2	236	282	81	17	81	0	2	1.062	0	0	0	0	0.8	1.4
MSZ109-07PP	2	165	320	52	46	52	0	2	1.059	0	0	0	0	1.8	0.7
MSZ443-3P	2	159	383	42	57	42	0	1	1.076	0	0	0	0	nd	1.1
MSZ602-2PP	2	150	210	71	26	71	0	3	1.061	0	0	0	0	2.2	0.4

Table 8

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, PIGMENTED LINES
MONTCALM RESEARCH CENTER
May 7 to September 7, 2018 (123 days)
DD Base 40°F 3236[5]

		CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]					
LINE	N	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	Bruise[4]
MSAA706-7PP	2	111	144	77	22	77	0	1	1.054	0	0	0	0	1.8	0.4
MSZ609-1P	1	94	196	48	38	48	0	14	1.074	0	10	0	0	2	1.3
MEAN		324	409						1.064					1.8	1.1
$HSD_{0.05}$		288	291						0.009						

[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]BRUISE: Simulated blackspot bruise test, average number of spots per tuber.
[5]Enviroweather: Entrican Station. Planting to vine kill

Plant Date: 5/7/2018
Vine Kill: 8/31/2018
Days from planting to vine kill: 116

Table 9

2016-2018 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	3-YR* AVG.	2018 RATING	2018 WORST	2018 N	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N
Sorted by ascending 2018 Average Rating;										
Goldrush Russet	0.8	0.3	0.5	3.0	1.5	2.0	3.0	0.5	1.0	4.0
MSAA101-1RR	-	0.5	0.5	3.0						
MSX177-7Y	1.0	0.5	0.5	3.0	1.2	1.5	3.0	1.3	1.5	4.0
MSZ109-05RR	0.5	0.5	1.0	3.0	0.7	1.0	3.0	0.4	0.5	4.0
MSZ219-01^{PVYR}	0.8	0.5	0.5	3.0	1.0	1.5	3.0	0.9	1.5	4.0
MSY507-02	1.0*	0.7	1.0	3.0	1.3	1.5	3.0			
MSZ222-08	-	0.7	1.0	3.0						
MSZ242-09	1.2	0.7	1.0	3.0	1.7	2.0	3.0	1.1	1.5	4.0
AF5312-1Rus	0.9*	0.8	1.5	3.0	1.0	1.5	3.0			
CO09036-2RUS	-	0.8	1.5	3.0						
Mountain Gem (A03158-2TERUS)	-	0.8	1.5	3.0						
MSAA161-4RY	-	0.8	1.0	3.0						
MSX324-1P	0.8	0.8	1.0	3.0	0.8	1.5	6.0	0.9	1.5	4.0
MSZ022-14	-	0.8	1.0	3.0						
MSZ022-16	1.1*	0.8	1.0	3.0	1.3	1.5	3.0			
MSZ102-5	1.1*	0.8	1.0	3.0	1.3	1.5	3.0			
MSZ219-13	0.7	0.8	1.0	3.0	0.5	0.5	3.0	0.9	1.0	4.0
MSZ219-14	0.8	0.8	1.0	3.0	0.7	1.0	3.0	0.8	1.0	4.0
MSZ242-03	-	0.8	1.0	3.0						
Mystery Splash	-	0.8	1.5	3.0						
Caribou Russet	1.3*	1.0	1.5	3.0				1.6	2.0	4.0
MSBB313-01Rus	-	1.0	1.5	3.0						
MSV177-1	-	1.0	1.5	3.0						
MSV313-2	1.0	1.0	1.5	3.0	1.0	1.5	3.0	1.1	2.0	4.0
MSZ052-31	-	1.0	1.0	3.0						
MSZ107-01PP	1.0	1.0	1.0	3.0	1.0	1.5	3.0	0.9	1.0	4.0
MSZ109-08PP	0.9	1.0	1.5	3.0	0.7	1.0	3.0	1.0	1.0	4.0
MSZ219-46	1.0*	1.0	1.0	3.0	1.0	1.5	3.0			
MSZ269-18	-	1.0	1.0	3.0						
MSZ269-1Y	1.5*	1.0	1.5	3.0	2.0	2.5	3.0			
MSZ428-1PP	1.3*	1.0	1.0	3.0	1.5	1.5	3.0			
MSZ590-1	1.2*	1.0	1.0	3.0	1.3	1.5	3.0			
CO07015-4RUS	-	1.2	1.5	3.0						
MSAA061-7	-	1.2	1.5	3.0						
MSW353-3	1.0*	1.2	1.5	3.0				0.9	1.0	4.0
MSX194-3	-	1.2	1.5	3.0						
MSZ022-07	1.1*	1.2	2.0	3.0	1.0	2.0	3.0			
MSZ109-10PP	1.6	1.2	1.5	3.0	1.7	3.0	3.0	1.9	2.5	4.0
MSZ118-8	1.3*	1.2	1.5	3.0	1.3	1.5	3.0			
MSZ222-19	1.1	1.2	1.5	3.0	0.8	1.0	3.0	1.3	2.0	4.0
MSZ246-1	1.3*	1.2	1.5	3.0	1.3	2.0	3.0			
MSZ407-2Y	1.2*	1.2	1.5	3.0	1.2	1.5	3.0			
MSZ427-1R	1.7*	1.2	1.5	3.0				2.3	3.0	4.0
Silverton Russet	**1.2***	**1.2**	**1.5**	**3.0**				**1.3**	**2.0**	**4.0**
W14176-14rus	-	1.2	1.5	3.0						
A06021-1TRus	1.4*	1.3	1.5	3.0	1.5	2.0	3.0			
AF4138-8	1.4*	1.3	1.5	3.0	1.5	2.0	3.0			
AF5406-7Rus	-	1.3	2.0	3.0						
Red Norland	**1.3**	**1.3**	**1.5**	**6.0**	**1.4**	**2.0**	**6.0**	**1.3**	**1.5**	**4.0**

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LINE	3-YR* AVG.	2018 RATING	2018 WORST	2018 N	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N
Isle Royale (MSX569-1R)	1.6	1.3	2.0	3.0	1.5	2.5	6.0	1.9	2.0	4.0
MSAA076-6	-	1.3	1.5	3.0						
MSAA244-1	-	1.3	1.5	3.0						
MSW100-1	1.1*	1.3	1.5	3.0				0.9	1.0	4.0
MSW119-2	1.3*	1.3	1.5	3.0				1.3	1.5	4.0
MSW502-4	1.2*	1.3	1.5	3.0				1.1	1.5	4.0
MSX472-2	-	1.3	2.0	3.0						
MSY111-1	1.4	1.3	1.5	3.0	1.3	2.0	3.0	1.6	2.0	4.0
MSZ020-08	-	1.3	1.5	3.0						
MSZ022-19	1.6*	1.3	1.5	3.0	1.8	2.0	3.0			
MSZ062-10	1.0*	1.3	2.0	3.0				0.6	1.0	4.0
MSZ096-03	-	1.3	2.0	3.0						
MSZ242-13	1.3	1.3	1.5	3.0	1.5	2.0	3.0	1.0	1.5	4.0
MSZ248-10	1.3*	1.3	2.5	3.0	1.2	1.5	3.0			
MSZ413-6P	-	1.3	2.0	3.0						
MSZ513-2	1.4*	1.3	2.0	3.0	1.5	1.5	3.0			
Soraya	1.6	1.3	1.5	3.0	2.0	2.0	3.0	1.5	2.0	4.0
W9576-11Y	1.3*	1.3	2.0	3.0	1.3	1.5	3.0			
AF5245-1P	1.4*	1.5	2.0	3.0	1.3	1.5	3.0			
MSAA166-2P	-	1.5	2.0	3.0						
MSAA168-8	-	1.5	2.0	3.0						
MSAA174-1	-	1.5	2.0	3.0						
MSAA182-3R	-	1.5	2.0	3.0						
MSAA196-1	-	1.5	2.0	3.0						
MST252-1Y	1.3*	1.5	1.5	3.0				1.0	1.5	4.0
MSV179-1	1.6	1.5	1.5	1.0	1.8	2.0	3.0	1.3	1.5	3.0
MSV443-1PP	-	1.5	2.0	3.0						
MSX225-2	1.3	1.5	2.0	3.0	1.2	1.5	3.0	1.3	1.5	4.0
MSZ052-14	-	1.5	2.0	3.0						
MSZ242-07	1.4*	1.5	2.0	3.0	**1.3**	2.0	3.0			
MSZ598-2	-	1.5	2.0	3.0						
MSZ709-04	-	1.5	2.0	3.0						
W13027-46Rus	-	1.5	2.0	3.0						
W14176-5rus	-	1.5	2.0	3.0						
CO05068-1RUS	-	1.7	2.0	3.0						
CO07049-1RUS	-	1.7	2.5	3.0						
Huron Chipper (MSW485-2)	1.8	1.7	2.0	3.0	1.8	2.5	3.0	1.8	2.0	4.0
MSAA161-1PY	-	1.7	2.0	3.0						
MSAA183-2PY	-	1.7	2.0	3.0						
MSAA217-3	-	1.7	2.5	3.0						
MSAA353-1	-	1.7	2.0	3.0						
MSU379-1	2.0*	1.7	2.0	3.0				2.3	2.5	4.0
MSV093-1Y	1.7*	1.7	2.0	3.0				1.8	2.0	4.0
MSV358-3	1.7	1.7	2.0	3.0	1.5	2.0	3.0	1.9	2.0	4.0
MSW044-01	1.6*	1.7	2.0	3.0				1.5	1.5	4.0
MSW537-6	1.9*	1.7	2.0	3.0				2.1	2.5	4.0
MSZ120-4	-	1.7	2.0	3.0						
MSZ200-6	-	1.7	2.0	3.0						
MSZ615-2	1.4*	1.7	2.0	3.0	1.2	1.5	3.0			
Queen Anne	1.3*	1.7	2.0	3.0	1.0	1.5	3.0			
W13015-17Rus	-	1.7	2.5	3.0						

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W8890-1R	2.0*	1.7	2.5	3.0	2.3	2.5	3.0			
MSZ609-1P	-	1.8	2.5	2.0						
AF5280-5	-	1.8	2.5	3.0						
Mackinaw (MSX540-4)[PVYR, LBR]	1.8	1.8	2.0	3.0	2.2	2.5	3.0	1.3	2.0	4.0
MSAA085-1	-	1.8	2.0	3.0						
MSAA706-7PP	-	1.8	3.0	3.0						
MSAA725-3	-	1.8	2.0	3.0						
MSV111-02[LBMR]	1.5	1.8	2.0	3.0	1.7	2.0	3.0	1.0	1.5	4.0
MSV498-1	1.4	1.8	2.0	3.0	1.2	1.5	3.0	1.1	1.5	4.0
MSV507-007	1.9	1.8	2.5	3.0	2.0	2.0	3.0	2.0	2.0	4.0
MSV507-012	1.5	1.8	2.0	3.0	1.2	1.5	3.0	1.5	2.0	4.0
MSX398-2	-	1.8	2.0	3.0						
MSY156-2	1.5	1.8	2.0	3.0	1.3	1.5	3.0	1.3	1.5	4.0
MSZ092-02	-	1.8	2.0	3.0						
MSZ109-07PP	-	1.8	2.0	3.0						
MSZ268-1Y	-	1.8	2.5	3.0						
MSZ436-2SPL	1.7*	1.8	2.0	3.0				1.5	2.0	4.0
ND102663B-3R	-	1.8	2.0	3.0						
NY149	1.8*	1.8	2.0	3.0	1.8	2.0	3.0			
Pike	**1.2**	**1.8**	**2.0**	**6.0**	**0.7**	**1.0**	**3.0**	**1.2**	**1.5**	**8.0**
Vanguard (TX08352-5Rus)	1.4	1.8	2.5	3.0	1.3	1.5	3.0	1.1	2.0	4.0
W13008-1rus	1.5*	1.8	2.5	3.0	1.2	1.5	3.0			
A08433-4VRRUS	2.1*	2.0	2.5	3.0	2.2	2.5	3.0			
CW08071-2RUS	-	2.0	2.5	3.0						
Lamoka	**1.8**	**2.0**	**2.5**	**3.0**	**1.7**	**2.0**	**3.0**	**1.6**	**2.0**	**4.0**
MSAA196-6	-	2.0	2.5	3.0						
MSAA228-1	-	2.0	2.5	3.0						
MSAA266-1	-	2.0	2.5	3.0						
MSL211-3	-	2.0	2.0	3.0						
MSS514-1PP	-	2.0	2.5	3.0						
MSW064-1	1.7*	2.0	2.0	3.0	1.3	1.5	3.0			
MSW075-1	1.6	2.0	2.0	3.0	1.2	1.5	3.0	1.6	2.5	4.0
MSX245-2Y	1.7	2.0	2.0	3.0	1.5	1.5	3.0	1.5	2.0	4.0
MSX324-2R	-	2.0	2.0	3.0						
MSZ107-6PP	2.2	2.0	2.5	3.0	2.7	3.0	3.0	1.8	2.0	4.0
MSZ248-02	-	2.0	2.5	3.0						
MSZ427-3R	1.9*	2.0	2.5	3.0				1.8	2.5	4.0
ND1232B-2RY	-	2.0	2.5	3.0						
Reveille Russet (ATX91137-1Rus)	1.8	2.0	2.5	3.0	1.7	2.5	3.0	1.6	2.0	4.0
W10612-8RUS	-	2.0	2.0	3.0						
W13103-2Y	1.6*	2.0	2.5	3.0	1.2	1.5	3.0			
W9968-5	2.0*	2.0	2.5	3.0	2.0	2.5	3.0			
MSX156-1Y	-	2.1	2.5	5.0						
Cerata	2.0*	2.2	2.5	3.0	1.8	2.0	3.0			
Manistee	2.4	2.2	2.5	3.0	2.3	2.5	3.0	2.6	3.0	4.0
MSAA127-7PP	-	2.2	2.5	3.0						
MSAA168-3	-	2.2	2.5	3.0						
MSAA232-4	-	2.2	2.5	3.0						
MSAA570-3	-	2.2	2.5	3.0						
MSAA571-3Y	-	2.2	2.5	3.0						

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MSAA678-1	-	2.2	2.5	3.0						
MSV507-001	2.3*	2.2	2.5	3.0				2.5	2.5	4.0
MSW248-2	2.0*	2.2	2.5	3.0				1.8	2.0	4.0
MSW343-2R	1.7	2.2	3.0	3.0	1.2	1.5	3.0	1.8	2.0	4.0
MSW502-3	2.0*	2.2	2.5	3.0				1.9	2.0	4.0
MSX269-4Y	-	2.2	2.5	3.0						
MSX293-1Y[LBR]	2.1*	2.2	2.5	3.0				2.0	2.5	4.0
MSX354-06Y	-	2.2	2.5	3.0						
MSZ144-4Y	-	2.2	2.5	3.0						
MSZ443-1PP	1.4	2.2	2.5	3.0	0.8	1.5	3.0	1.3	1.5	4.0
MSZ602-2PP	1.8	2.2	2.5	3.0	2.0	2.5	3.0	1.3	2.0	4.0
ND113113B-2PSY	-	2.2	2.5	3.0						
NY152	2.1*	2.2	2.5	3.0				2.1	2.5	4.0
Alegria	2.0	2.3	2.5	3.0	2.0	2.0	3.0	1.8	2.0	4.0
MSAA127-1PP	-	2.3	3.0	3.0						
MSAA131-2	-	2.3	2.5	3.0						
MSAA157-2PY	-	2.3	2.5	3.0						
MSZ159-3	-	2.3	2.5	3.0						
MSZ194-2	-	2.3	2.5	3.0						
MSZ510-4	2.3*	2.3	3.0	3.0	2.3	2.5	3.0			
ND081571-2R	-	2.3	3.0	3.0						
A07061-6Rus	2.6*	2.5	3.0	3.0	2.7	3.0	3.0			
AF5091-8Rus	2.4	2.5	3.0	3.0	2.5	3.0	3.0	2.3	2.5	4.0
MSW476-4R	2.0*	2.5	3.0	3.0	1.5	2.5	3.0			
MSX443-3P	-	2.5	4.0	3.0						
MSZ052-02	2.0*	2.5	3.0	3.0	1.5	2.0	3.0			
Onaway	**2.0**	**2.5**	**3.0**	**3.0**	**2.0**	**2.0**	**3.0**	**1.6**	**2.0**	**4.0**
Orlena	-	2.5	2.5	3.0						
QSNDSU07-04R	1.9	2.5	3.0	3.0	1.3	2.0	6.0	1.9	2.0	4.0
Reba	**2.3**	**2.5**	**2.5**	**3.0**	**2.2**	**3.0**	**6.0**	**2.1**	**2.5**	**8.0**
Yukon Gold	**2.5**	**2.6**	**3.5**	**6.0**	**2.2**	**2.5**	**6.0**	**2.6**	**3.0**	**4.0**
BNC182-5	-	2.7	3.0	3.0						
Jazzy	-	2.7	3.0	3.0						
MSAA208-2	-	2.7	3.5	3.0						
MSAA240-6	-	2.7	4.0	3.0						
MSW038-4Y	-	2.7	3.0	3.0						
MSW148-1P	2.5	2.7	3.0	3.0	2.3	2.5	3.0	2.5	2.5	4.0
MSW316-3PY	2.1	2.7	3.5	3.0	1.7	3.0	6.0	1.9	2.5	4.0
MSX526-2Y	2.4*	2.7	3.0	3.0	2.2	3.0	3.0			
MSZ025-2	2.4*	2.7	3.0	3.0	2.2	2.5	3.0			
ND1243-1PY	2.7*	2.7	3.0	3.0	2.7	3.0	3.0			
W8405-1R	2.3*	2.7	3.0	3.0	2.0	2.5	3.0			
A071012-4BFRUS	-	2.8	3.0	3.0						
AC03452-2W	-	2.8	3.0	3.0						
Bonnata	-	2.8	3.5	3.0						
CO02321-4W	-	2.8	3.5	3.0						
MSV235-2PY[LBR]	2.4	2.8	3.0	3.0	1.8	3.0	3.0	2.5	3.0	4.0
ND12128B-1R	-	2.8	3.0	3.0						
Russet Norkotah	**2.3**	**2.8**	**4.0**	**3.0**	**1.9**	**2.5**	**6.0**	**2.1**	**2.5**	**4.0**
AF4831-2R	2.7	3.0	3.5	3.0	2.8	3.5	3.0	2.3	3.0	4.0

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LINE	3-YR* AVG.	2018 RATING	2018 WORST	2018 N	2017 RATING	2017 WORST	2017 N	2016 RATING	2016 WORST	2016 N
Atlantic	**2.8**	**3.0**	**3.5**	**3.0**	**2.5**	**3.0**	**4.0**	**2.8**	**3.0**	**8.0**
B2904-2	-	3.0	3.5	3.0						
BNC311-4	-	3.0	3.5	3.0						
MSAA120-1	-	3.0	3.5	3.0						
MSX497-6[LBR]	2.5	3.0	3.5	3.0	2.5	3.0	3.0	2.1	2.5	4.0
Snowden	**2.6**	**3.0**	**3.5**	**3.0**	**2.5**	**3.0**	**6.0**	**2.4**	**2.5**	**8.0**
AC00206-2W	-	3.2	3.5	3.0						
MSZ100-03	-	3.2	4.0	3.0						
W10594-16RUS	-	3.2	4.0	3.0						
B2869-29	-	3.3	4.0	3.0						
CO02033-1W	-	3.3	4.0	3.0						
CO98012-5R	-	3.3	3.5	3.0						
Laperla	-	3.3	3.5	3.0						
MSZ547-3	-	3.3	4.0	3.0						
ND1241-1Y	3.3*	3.3	4.5	3.0	3.2	4.0	3.0			
WAF10612-1RUS	-	3.3	4.0	3.0						
MSAA037-1	-	3.5	4.0	3.0						
MSW242-5Y	-	3.5	4.0	3.0						
MSZ706-1	-	3.5	4.5	3.0						
Wendy	3.2*	3.5	4.0	3.0	2.8	3.0	3.0			
AC05153-1W	-	3.7	4.5	3.0						
AF5179-4Rus	3.9*	4.0	4.0	3.0	3.8	4.5	3.0			
MEAN		1.9			1.6			1.6		
$HSD_{0.05}$ =		**1.9**			**2.0**			**1.7**		

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.

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SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE	2018 RATING	2018 N	LINE		2018 RATING	2018 N
Sorted by ascending 2018 Rating:						
MSDD345-01	0.0	1	MSDD543-01		0.5	1
MSBB008-03	0.5	1	MSDD560-01		0.5	1
MSBB017-01	0.5	1	MSEE790-05	*2x*	0.5	1
MSBB060-01	0.5	1	MSEE798-02	*2x*	0.5	1
MSBB075-01Y	0.5	1	MSEE798-06	*2x*	0.5	1
MSBB179-01	0.5	1	MSEE798-10	*2x*	0.5	1
MSBB610-09Y	0.5	1	MSFF729-02	*2x*	0.5	1
MSBB610-13	0.5	1	MSFF854-05	*2x*	0.5	1
MSBB613-04	0.5	1	VT.SUP.h27	*Hap*	0.5	1
MSBB618-02	0.5	1	VT.SUP.h40	*Hap*	0.5	1
MSBB625-02	0.5	1	VT.SUP.h62	*Hap*	0.5	1
MSBB635-15	0.5	1	VT.SUP.h82	*Hap*	0.5	1
MSBB636-11	0.5	1	VT.SUP.h83	*Hap*	0.5	1
MSBB637-06	0.5	1	VT.SUP.h89	*Hap*	0.5	1
MSCC058-01	0.5	1	ATL.M.404	*Hap*	1.0	1
MSCC374-02	0.5	1	ATL.M.426	*Hap*	1.0	1
MSCC622-01Y	0.5	1	ATL.V.017	*Hap*	1.0	1
MSCC722-02RR (mini)	0.5	1	MSBB058-01		1.0	1
MSDD001-01	0.5	1	MSBB222-01		1.0	1
MSDD031-01	0.5	1	MSBB617-02		1.0	1
MSDD039-01	0.5	1	MSBB626-06		1.0	1
MSDD039-02	0.5	1	MSBB633-18		1.0	1
MSDD042-01	0.5	1	MSCC084-01		1.0	1
MSDD045-01	0.5	1	MSCC720-01WP		1.0	1
MSDD074-02	0.5	1	MSCC864-20S1-04	*2x*	1.0	1
MSDD089-02	0.5	1	MSCC864-20S1-05	*2x*	1.0	1
MSDD091-01	0.5	1	MSDD006-07		1.0	1
MSDD094-02	0.5	1	MSDD094-01		1.0	1
MSDD138-02	0.5	1	MSDD095-01		1.0	1
MSDD226-01	0.5	1	MSDD107-01		1.0	1
MSDD226-02	0.5	1	MSDD108-01		1.0	1
MSDD230-02	0.5	1	MSDD208-02		1.0	1
MSDD321-03	0.5	1	MSDD211-01		1.0	1
MSDD342-01	0.5	1	MSDD211-03		1.0	1
MSDD383-01	0.5	1	MSDD218-01		1.0	1
MSDD489-01	0.5	1	MSDD219-02		1.0	1
MSDD508-01	0.5	1	MSDD230-01		1.0	1
MSDD516-01	0.5	1	MSDD325-01		1.0	1

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LINE		2018 RATING	2018 N	LINE		2018 RATING	2018 N
Sorted by ascending 2018 Rating:							
MSDD359-01		1.0	1	MSCC132-01		1.5	1
MSDD375-01		1.0	1	MSCC168-01		1.5	1
MSDD376-3		1.0	1	MSCC208-01		1.5	1
MSDD399-01		1.0	1	MSCC374-01Y (mini)		1.5	1
MSDD403-01		1.0	1	MSCC515-02Y		1.5	1
MSDD403-04		1.0	1	MSCC553-01R		1.5	1
MSDD448-01		1.0	1	MSCC858-03	*2x*	1.5	1
MSDD455-01		1.0	1	MSCC863-36	*2x*	1.5	1
MSDD463-02		1.0	1	MSDD034-01		1.5	1
MSDD512-02		1.0	1	MSDD040-01		1.5	1
MSDD542-02		1.0	1	MSDD040-02		1.5	1
MSDD543-04		1.0	1	MSDD088-01		1.5	1
MSDD881-14	*2x*	1.0	1	MSDD149-01		1.5	1
MSDD883-05	*2x*	1.0	1	MSDD190-01		1.5	1
MSEE757-01	*2x*	1.0	1	MSDD208-01		1.5	1
MSEE798-14	*2x*	1.0	1	MSDD208-03		1.5	1
MSEE824-04S1-02	*2x*	1.0	1	MSDD226-03		1.5	1
MSEE853-27	*2x*	1.0	1	MSDD254-01		1.5	1
MSEE853-30	*2x*	1.0	1	MSDD307-01		1.5	1
MSFF707-02	*2x*	1.0	1	MSDD312-01		1.5	1
MSFF776-02	*2x*	1.0	1	MSDD321-01		1.5	1
MSFF862-02	*2x*	1.0	1	MSDD339-01		1.5	1
MSFF865-02	*2x*	1.0	1	MSDD342-02		1.5	1
VT.SUP.h94	*Hap*	1.0	1	MSDD402-01		1.5	1
VT.SUP.h99	*Hap*	1.0	1	MSDD491-01		1.5	1
ATL.M.170	*Hap*	1.5	1	MSDD503-01		1.5	1
ATL.M.402	*Hap*	1.5	1	MSDD505-01		1.5	1
ATL.V.044	*Hap*	1.5	1	MSDD543-02		1.5	1
MSBB078-01		1.5	1	MSDD553-01		1.5	1
MSBB166-01		1.5	1	MSDD883-19	*2x*	1.5	1
MSBB213-01SPL		1.5	1	MSEE779-05	*2x*	1.5	1
MSBB250-01PP		1.5	1	MSEE781-01	*2x*	1.5	1
MSBB305-02PSpl		1.5	1	MSEE790-04	*2x*	1.5	1
MSBB610-24Y		1.5	1	MSEE801-01	*2x*	1.5	1
MSBB623-12		1.5	1	MSEE815-06	*2x*	1.5	1
MSBB631-04		1.5	1	MSEE847-12	*2x*	1.5	1
MSCC009-01		1.5	1	MSEE853-16	*2x*	1.5	1
MSCC081-01		1.5	1	MSFF691-02	*2x*	1.5	1

Table 10

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

2018 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2018 RATING	2018 N	LINE		2018 RATING	2018 N
Sorted by ascending 2018 Rating:							
MSFF694-02	*2x*	1.5	1	MSDD221-01		2.0	1
MSFF752-01	*2x*	1.5	1	MSDD251-01		2.0	1
MSFF764-01	*2x*	1.5	1	MSDD251-02		2.0	1
MSFF829-01	*2x*	1.5	1	MSDD256-01		2.0	1
MSFF859-01	*2x*	1.5	1	MSDD295-01		2.0	1
VT.SUP.h56	*Hap*	1.5	1	MSDD296-03		2.0	1
VT.SUP.h79	*Hap*	1.5	1	MSDD350-01		2.0	1
VT.SUP.h95	*Hap*	1.5	1	MSDD354-01		2.0	1
VT.SUP.h96	*Hap*	1.5	1	MSDD370-02		2.0	1
ATL.HT.118	*Hap*	2.0	1	MSDD376-01		2.0	1
ATL.M.184	*Hap*	2.0	1	MSDD376-04		2.0	1
ATL.M.427	*Hap*	2.0	1	MSDD385-01		2.0	1
MSBB061-01		2.0	1	MSDD386-02		2.0	1
MSBB190-01		2.0	1	MSDD396-01		2.0	1
MSBB210-A		2.0	1	MSDD448-02		2.0	1
MSBB230-01		2.0	1	MSDD452-01		2.0	1
MSBB238-01RY		2.0	1	MSDD457-01		2.0	1
MSBB618-09		2.0	1	MSDD463-01		2.0	1
MSBB626-11		2.0	1	MSDD471-01		2.0	1
MSBB637-17		2.0	1	MSDD505-02		2.0	1
MSCC302-01		2.0	1	MSDD510-01		2.0	1
MSCC447-1WR		2.0	1	MSDD530-01		2.0	1
MSCC512-01PP		2.0	1	MSDD543-03		2.0	1
MSCC614-1RYSPL		2.0	1	MSDD565-01		2.0	1
MSCC724-01Y		2.0	1	MSDD883-05S1-01	*2x*	2.0	1
MSCC846-05	*2x*	2.0	1	MSEE774-01	*2x*	2.0	1
MSCC864-17	*2x*	2.0	1	MSEE774-05	*2x*	2.0	1
MSCC864-19A	*2x*	2.0	1	MSEE774-08	*2x*	2.0	1
MSCC864-20	*2x*	2.0	1	MSEE780-02	*2x*	2.0	1
MSDD009-01		2.0	1	MSEE783-05	*2x*	2.0	1
MSDD053-01		2.0	1	MSEE790-04 ?	*2x*	2.0	1
MSDD089-01		2.0	1	MSEE798-07	*2x*	2.0	1
MSDD095-02		2.0	1	MSEE798-09	*2x*	2.0	1
MSDD098-01		2.0	1	MSEE805-01	*2x*	2.0	1
MSDD098-02		2.0	1	MSEE824-04	*2x*	2.0	1
MSDD152-01		2.0	1	MSEE824-06	*2x*	2.0	1
MSDD211-02		2.0	1	MSEE844-07	*2x*	2.0	1
MSDD219-01		2.0	1	MSEE847-04	*2x*	2.0	1

2018 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2018 RATING	2018 N	LINE		2018 RATING	2018 N
Sorted by ascending 2018 Rating:							
MSEE853-04	*2x*	2.0	1	MSEE853-05	*2x*	2.5	1
MSEE853-06	*2x*	2.0	1	MSEE853-07	*2x*	2.5	1
MSEE853-09	*2x*	2.0	1	MSEE853-08	*2x*	2.5	1
MSEE853-11	*2x*	2.0	1	MSEE853-18	*2x*	2.5	1
MSFF691-04	*2x*	2.0	1	MSEE853-28	*2x*	2.5	1
MSFF694-01	*2x*	2.0	1	MSEE858-02	*2x*	2.5	1
MSFF733-03	*2x*	2.0	1	MSEE872-03	*2x*	2.5	1
MSFF752-03	*2x*	2.0	1	MSFF826-01	*2x*	2.5	1
MSFF818-01	*2x*	2.0	1	MSFF833-03	*2x*	2.5	1
MSFF853-01	*2x*	2.0	1	MSFF848-03	*2x*	2.5	1
VT.SUP.h47	*Hap*	2.0	1	MSFF864-01	*2x*	2.5	1
VT.SUP.h65	*Hap*	2.0	1	VT.SUP.h24A	*Hap*	2.5	1
ATL.M.192	*Hap*	2.5	1	VT.SUP.h75	*Hap*	2.5	1
ATL.M.424	*Hap*	2.5	1	ATL.M.109	*Hap*	3.0	1
ATL.M.429	*Hap*	2.5	1	ATL.M.151	*Hap*	3.0	1
MSBB270-01Spl		2.5	1	MSCC845-06	*2x*	3.0	1
MSBB308-02P		2.5	1	MSDD005-01		3.0	1
MSCC282-01WR		2.5	1	MSDD074-01		3.0	1
MSCC851-01	*2x*	2.5	1	MSDD137-01		3.0	1
MSCC853-01	*2x*	2.5	1	MSDD148-01		3.0	1
MSCC857-05	*2x*	2.5	1	MSDD224-01		3.0	1
MSCC864-28	*2x*	2.5	1	MSDD224-02		3.0	1
MSDD051-01		2.5	1	MSDD254-02		3.0	1
MSDD138-01		2.5	1	MSDD297-01		3.0	1
MSDD146-01		2.5	1	MSDD311-02		3.0	1
MSDD219-03		2.5	1	MSDD321-02		3.0	1
MSDD253-01		2.5	1	MSDD347-01		3.0	1
MSDD309-02		2.5	1	MSDD357-1		3.0	1
MSDD311-01		2.5	1	MSDD359-02		3.0	1
MSDD370-01		2.5	1	MSDD365-01R		3.0	1
MSDD482-01		2.5	1	MSDD367-01		3.0	1
MSDD495-01		2.5	1	MSDD369-01		3.0	1
MSDD495-02		2.5	1	MSDD403-02		3.0	1
MSDD508-02		2.5	1	MSDD403-03		3.0	1
MSDD512-01		2.5	1	MSDD449-01		3.0	1
MSDD519-01		2.5	1	MSDD463-03		3.0	1
MSDD559-01		2.5	1	MSDD470-01		3.0	1
MSEE791-07	*2x*	2.5	1	MSDD530-02		3.0	1

Table 10

2018 SCAB DISEASE EARLY GENERATION TRIAL SUMMARY
SCAB NURSERY, MONTCALM RESEARCH CENTER, MI

LINE		2018 RATING	2018 N	LINE	2018 RATING	2018 N
Sorted by ascending 2018 Rating:						
MSDD542-01		3.0	1			
Atlantic		**3.0**	**3**			
Snowden		**3.0**	**3**			
MSDD193-01		3.5	1			
MSDD281-01		3.5	1			
MSDD291-01		3.5	1			
MSDD296-01		3.5	1			
MSDD423-01R		3.5	1			
ATL.V.016	*Hap*	4.0	1			
MSCC549-02WP		4.0	1			
MSDD291-02		4.0	1			
MSDD296-02		4.0	1			
MSDD309-01		4.0	1			
MSDD386-01		4.0	1			

Table 11

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2018 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									
Manistee (MSL292-A)	1.078	0	4	10	8	3	0	0	2.4
MSZ022-07	1.072	3	2	4	3	6	1	16	2.5
MSZ096-03	1.077	3	1	9	6	3	3	12	2.6
MSZ219-46	1.073	1	4	6	8	4	3	4	2.7
MSZ025-02	1.073	2	2	5	9	5	3	8	2.8
MSZ052-02	1.072	0	2	8	8	4	3	0	2.9
MSZ222-19	1.082	0	1	7	7	5	5	0	3.2
MSZ242-07	1.088	0	1	7	7	5	5	0	3.2
MSZ219-14	1.077	1	0	5	9	5	5	4	3.3
MSZ219-01	1.078	0	1	4	7	8	5	0	3.5
MSZ246-1	1.083	0	0	6	5	8	6	0	3.6
MSZ052-14	1.073	0	1	6	5	3	10	0	3.6
MSZ219-13	1.075	0	0	3	9	6	7	0	3.7
MSZ248-10	1.076	1	0	2	8	7	8	4	3.7
Mackinaw (MSX540-4)	1.085	0	0	4	6	5	10	0	3.8
MSZ242-13	1.090	0	1	1	5	5	14	0	4.2
MSZ242-09	1.083	0	0	1	3	9	12	0	4.3
Atlantic	**1.085**	**0**	**0**	**1**	**2**	**6**	**10**	**0**	**4.3**
Snowden	**1.080**	**0**	**0**	**2**	**0**	**8**	**15**	**0**	**4.4**
ADAPTATION TRIAL, CHIP AND TABLESTOCK LINES									
MSZ109-05RR	1.061	1	14	10	0	0	0	4	1.4
MSV093-1Y	1.066	3	9	11	2	1	0	12	1.6
MSV358-3	1.078	5	9	6	2	1	2	20	1.6
Pike	**1.079**	**6**	**6**	**5**	**6**	**1**	**1**	**24**	**1.7**
MSU379-1	1.072	0	4	3	4	1	0	0	2.2
HuronChipper (MSW485-2)	1.083	3	3	8	8	3	0	12	2.2
MSV235-2PY	1.070	0	7	7	7	4	1	0	2.4
MSX156-1Y	1.062	0	6	9	3	1	5	0	2.6
MSY156-02	1.078	1	1	9	11	2	1	4	2.6
MSW064-01	1.081	0	0	6	2	4	1	0	3.0
MSV313-2	1.077	0	5	6	3	4	7	0	3.1
MSX245-2Y	1.081	2	2	5	4	6	6	8	3.1
Lamoka	**1.078**	**0**	**0**	**6**	**4**	**9**	**0**	**0**	**3.2**
MSW075-01	1.074	1	1	4	6	9	4	4	3.3
MSW502-4	1.083	0	1	6	6	4	8	0	3.5
NY152	1.075	0	1	4	3	5	6	0	3.6
MSX225-02	1.075	0	2	1	5	8	9	0	3.8
MSV498-1	1.072	0	0	3	6	7	9	0	3.9
MSW044-01	1.080	0	0	1	10	4	10	0	3.9
MSV507-007	1.074	0	0	1	5	4	9	0	4.1
NORTH CENTRAL REGION TRIAL									
ND081571-2R	1.054	25		0	0	0	0	100	0.0
ND102663B-3R	1.061	22	3	0	0	0	0	88	0.1
MSZ109-08PP	1.060	20	4	0	0	0	0	83	0.2
MSZ109-10PP	1.060	18	7	0	0	0	0	72	0.3

Table 11

2018 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
Red Norland	**1.055**	**17**	**7**	**0**	**1**	**0**	**0**	**68**	**0.4**
MSZ107-06PP	1.069	13	10	0	0	0	0	57	0.4
Russet Norkotah	**1.066**	**14**	**10**	**1**	**0**	**0**	**0**	**56**	**0.5**
W13103-2Y	1.057	13	12	0	0	0	0	52	0.5
AND00272-1R	1.060	11	12	2	0	0	0	44	0.6
QSNDSU07-04	1.058	14	7	3	1	0	0	56	0.6
ND12128B-1R	1.066	9	12	4	0	0	0	36	0.8
W13008-1rus	1.067	8	13	2	2	0	0	32	0.9
W14176-14rus	1.084	6	13	7	0	0	0	23	1.0
W13015-17rus	1.073	8	9	6	2	0	0	32	1.1
W13027-46rus	1.069	7	7	9	1	1		28	1.3
ND1232B-2RY	1.069	5	9	3	1	4	0	23	1.5
MSU Red Marker #2	1.074	3	7	12	3	0	0	12	1.6
MSW316-3PY	1.066	3	7	6	7	2	0	12	1.9
MSR226-ARR	1.069	1	8	8	5	3	0	4	2.0
MSQ558-2RR	1.066	1	7	5	7	2	1	4	2.2
ND1243-1PY	1.072	0	7	5	7	3	3	0	2.6
ND113113B-2PSY	1.071	1	3	4	10	3	2	4	2.7
W14176-5rus	1.085	0	2	8	8	2	5	0	3.0
ND1241-1Y	1.096	0	2	9	6	2	6	0	3.0
RUSSET TRIAL									
Silverton Russet	1.065	16	9	0	0	0	0	64	0.4
W10594-16RUS	1.076	14	7	4	0	0	0	56	0.6
CO07015-4RUS	1.067	10	10	4	1	0	0	40	0.8
CO07049-1RUS	1.068	7	11	7	0	0	0	28	1.0
Reveille Russet (ATX91137-1Rus)	1.069	7	12	3	2	1	0	28	1.1
Caribou	1.072	7	12	3	2	1	0	28	1.1
CO09036-2RUS	1.073	1	15	9	0	0	0	4	1.3
Goldrush Russet	1.062	2	15	5	3	0	0	8	1.4
Russet Norkotah	**1.069**	**2**	**13**	**9**	**1**	**0**	**0**	**8**	**1.4**
AF5091-8RUS	1.065	4	8	12	1	0	0	16	1.4
AF5406-7RUS	1.075	6	7	9	2	1	0	24	1.4
A07061-6RUS	1.071	2	10	4	3	0	0	11	1.4
TX08352-5Rus (Vanguard)	1.060	0	11	14	1	0	0	0	1.6
AF5179-4RUS	1.084	4	6	8	7	1	0	15	1.8
A06021-1TRUS	1.077	1	8	9	7	0	0	4	1.9
WAF10612-1RUS	1.074	1	8	9	5	2	0	4	2.0
Mountain Gem (A03158-2TERUS)	1.069	0	6	13	5	1	0	0	2.0
AF5312-1RUS	1.066	1	4	12	5	3	0	4	2.2
CW08071-2RUS	1.073	0	7	8	5	0	5	0	2.5
A08433-4VRRUS	1.077	0	5	7	8	5	1	0	2.6
A071012-4BFRUS	1.086	0	2	6	7	4	6	0	3.2
W10612-8RUS	1.073	0	0	2	8	6	5	0	3.7
CO05068-1RUS	1.088	0	0	4	5	9	7	0	3.8
ADAPTATION TRIAL, TABLESTOCK LINES									
Red Norland	**1.055**	**22**	**3**	**0**	**0**	**0**	**0**	**88**	**0.1**

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MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2018 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	1.058	15	10	0	0	0	0	60	0.4
MSV111-2	1.069	16	7	1	1	0	0	64	0.5
MSZ428-1PP	1.066	14	10	1	0	0	0	56	0.5
MSZ109-10PP	1.061	16	7	3	0	0	0	62	0.5
MSZ413-6P	1.067	12	11	2	0	0	0	48	0.6
Yukon Gold	**1.066**	**13**	**9**	**3**	**0**	**0**	**0**	**52**	**0.6**
MSW316-03PY	1.069	11	4	4		0	0	58	0.6
MSZ107-06PP	1.072	11	12	2	0	0	0	44	0.6
MSV179-1	1.060	11	5	2	2	0	1	52	1.0
MSX398-2	1.077	9	10	2	3	0	0	38	1.0
MST252-1Y	1.064	6	11	6	2	0	0	24	1.2
MSX497-06	1.063	8	7	4	3	2	1	32	1.5
MSZ590-1	1.065	6	7	7	4	0	1	24	1.5
MSZ407-2Y	1.075	3	10	5	6	1	0	12	1.7
Onaway	**1.058**	**4**	**7**	**7**	**6**	**1**		**16**	**1.7**
MSX324-1P	1.076	3	5	11	6	1	0	12	1.9
MSZ598-2	1.065	0	9	7	2	3	4	0	2.4
PRELIMINARY TRIAL, CHIP-PROCESSING LINES									
MSAA228-1	1.074	12	7	1	0	0	0	60	0.5
AC00206-2W	1.069	8	9	2	1	0	0	40	0.8
AC03452-2W	1.067	10	6	4	1	0	0	48	0.8
MSAA725-3	1.069	8	9	2	0	1	0	40	0.9
AC05153-1W	1.071	6	10	3	1	0	0	30	1.0
MSAA208-2	1.085	7	7	6	0	0	0	35	1.0
MSZ100-03	1.067	6	8	2	3	0	0	32	1.1
MSZ144-4Y	1.068	2	7	4	0	0	0	15	1.2
MSZ092-02	1.073	5	6	6	2	0	0	26	1.3
MSZ242-03	1.076	3	8	6	2	1	0	15	1.5
B2904-2	1.080	7	3	5	2	2	1	35	1.6
MSAA266-1	1.071	4	5	7	4	1	0	19	1.7
MSX225-1	1.086	3	5	6	5	0	0	16	1.7
CO02321-4W	1.080	2	7	2	7	1	0	11	1.9
MSZ020-08	1.073	0	6	10	3	1	0	0	2.0
MSAA037-1	1.084	1	4	4	2	2	0	8	2.0
MSZ159-3	1.078	2	6	2	1	0	3	14	2.0
MSAA240-6	1.082	1	5	8	4	2	0	5	2.1
Pike	**1.080**	**2**	**6**	**5**	**4**	**4**	**0**	**10**	**2.1**
MSZ269-18	1.072	2	4	6	5	3	0	10	2.2
MSAA061-7	1.080	2	3	6	5	3	0	11	2.2
MSZ022-14	1.065	0	6	5	4	4	0	0	2.3
MSX177-7Y	1.076	1	7	5	5	2	3	4	2.4
BNC311-4	1.074	4	3	2	5	4	2	20	2.4
W9968-5	1.087	2	5	5	3	1	4	10	2.4
MSAA217-3	1.089	2	2	5	6	3	2	10	2.6
MSAA232-4	1.077	2	2	4	6	3	2	11	2.6
MSZ022-19	1.074	0	2	9	4	3	2	0	2.7
MSW537-6	1.088	0	2	6	8	5	0	0	2.8

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2018 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
CO02033-1W	1.083	2	3	4	1	4	5	11	2.9
MSZ194-2	1.078	0	5	3	4	3	4	0	2.9
MSZ200-6	1.072	0	2	5	4	6	3	0	3.2
MSAA085-1	1.076	2	1	2	6	4	5	10	3.2
B2869-29	1.087	0	4	3	3	3	7	0	3.3
Snowden	**1.081**	**0**	**1**	**5**	**5**	**5**	**4**	**0**	**3.3**
MSAA571-3Y	1.074	1	3	1	5	2	8	5	3.4
MSZ102-5	1.076	0	4	1	4	5	6	0	3.4
MSZ120-4	1.079	0	2	4	2	7	5	0	3.5
MSZ268-1Y	1.074	1	2	1	2	4	8	6	3.7
MSAA076-6	1.086	0	0	2	8	3	7	0	3.8
MSAA678-1	1.080	1	1	1	2	5	7	6	3.8
BNC182-5	1.081	0	2	2	2	2	12	0	4.0
MSAA570-3	1.080	0	0	0	4	5	4	0	4.0
MSAA353-1	1.077	0	0	0	8	2	9	0	4.1
MSZ248-02	1.067	0	0	0	5	6	8	0	4.2
PRELIMINARY TRIAL, TABLESTOCK LINES									
AF5280-5	1.058	17	8	0	0	0	0	68	0.3
NY149	1.071	13	8	3	1	0	0	52	0.7
Soraya	1.059	9	15	1	0	0	0	36	0.7
MSV177-1	1.079	8	14	3	0	0	0	32	0.8
Queen Anne	1.057	8	14	3	0	0	0	32	0.8
Jazzy	1.060	8	10	6	0	0	0	33	0.9
W9576-11Y	1.058	9	9	7	0	0	0	36	0.9
Bonnata	1.065	5	15	6	0	0	0	19	1.0
MSAA196-1	1.060	6	12	5	1	0	0	25	1.0
MSX526-02Y	1.066	5	14	5	1	0	0	20	1.1
MSAA196-6	1.061	5	14	3	1	2	0	20	1.2
Laperla	1.050	3	15	4	3	0	0	12	1.3
Wendy	1.062	0	18	7	0	0	0	0	1.3
MSL211-3	1.064	3	13	7	2	0	0	12	1.3
MSAA174-1	1.058	6	6	9	4	0	0	24	1.4
MSX293-1Y	1.074	3	12	5	5	0	0	12	1.5
MSZ510-4	1.062	3	9	7	2	1	0	14	1.5
Yukon Gold	**1.075**	**2**	**12**	**6**	**4**	**1**	**0**	**8**	**1.6**
Orlena	1.053	1	10	8	5	1	0	4	1.8
MSX472-2	1.068	2	6	9	6	2	0	8	2.0
AF4138-8	1.059	0	10	7	5	3	0	0	2.0
MSW119-2	1.070	2	8	7	4	3	1	8	2.0
MSZ615-2	1.065	2	6	9	5	3	0	8	2.0
MSZ513-2	1.066	1	8	9	4	0	3	4	2.1
MSZ706-1	1.078	1	6	5	8	5	0	4	2.4
MSAA168-8	1.073	0	6	7	8	2	2	0	2.5
Alegria	1.070	0	1	10	8	6	0	0	2.8
MSAA168-3	1.070	1	3	4	11	3	3	4	2.8
Reba	**1.069**	**0**	**1**	**8**	**11**	**2**	**3**	**0**	**2.9**

2018 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
PRELIMINARY TRIAL, PIGMENTED LINES									
MSZ436-2SPL	1.053	16	6	0	0	0	0	73	0.3
Cerata	1.061	19	5	1	0	0	0	76	0.3
MSZ107-01PP	1.070	18	5	1	0	0	0	75	0.3
MSAA182-3R	1.075	14	5	2	0	0	0	67	0.4
MSZ602-2PP	1.061	14	8	1	0	0	0	61	0.4
MSAA706-7PP	1.054	5	4	0	0	0	0	56	0.4
W8890-1R	1.056	13	11	1	0	0	0	52	0.5
MSW476-4R	1.072	13	11	0	1	0	0	52	0.6
MSX569-1R	1.052	14	6	5	0	0	0	56	0.6
MSZ109-07PP	1.059	11	5	4	0	0	0	55	0.7
MSAA127-7PP	1.055	13	7	4	1	0	0	52	0.7
MSZ427-1R	1.058	13	7	4	1	0	0	52	0.7
MSZ493-1PP	1.061	8	14	3	0	0	0	32	0.8
AF4831-2R	1.073	9	10	6	0	0	0	36	0.9
MSS514-1PP	1.060	3	8	0	1	0	0	25	0.9
CO98012-5R	1.065	9	7	8	0	1	0	36	1.1
MSZ433-3P	1.076	7	9	7	1	0	0	29	1.1
AF5245-1P	1.073	3	13	9	0	0	0	12	1.2
MSZ427-3R	1.051	9	6	8	2	0	1	35	1.3
MSAA127-1PP	1.051	6	1	5	3	0	0	40	1.3
MSZ609-1P	1.074	3	3	5	1	0	0	25	1.3
Mystery Splash	1.062	9	5	4	4	1	1	38	1.4
MSX324-2R	1.068	2	10	8	4	0	0	8	1.6
MSAA166-2P	1.068	1	12	8	4	0	0	4	1.6
MSAA161-1PY	1.076	7	7	5	4	2	1	27	1.6
MSAA183-2PY	1.062	2	10	4	4	1	0	10	1.6
MSAA161-4RY	1.068	3	10	6	3	2	0	13	1.6
MSAA157-2PY	1.067	2	9	4	8	2	0	8	2.0
MSAA101-1RR	1.076	0	8	7	5	3	1	0	2.3
W8405-1R	1.060	3	3	4	5	0	3	17	2.3
USPB/SFA TRIAL CHECK SAMPLES (Not bruised)									
Mackinaw (MSX540-4)	1.084	18	7	0	0	0	0	72	0.3
NDTX081648CB-13W	1.076	18	5	1	0	0	0	75	0.3
ND7519-4	1.082	17	8	0	0	0	0	68	0.3
NDA081453CAB-2C	1.076	15	9	1	0	0	0	60	0.4
W9968-5	1.08	15	6	4	0	0	0	60	0.6
Snowden	**1.078**	**10**	**15**	**0**	**0**	**0**	**0**	**40**	**0.6**
Lamoka	**1.077**	**11**	**11**	**3**	**0**	**0**	**0**	**44**	**0.7**
AF5429-3	1.073	14	7	1	2	1	0	56	0.8
MSW044-1	1.085	9	9	5	2	0	0	36	1.0
NY162	1.075	2	5	12	5	0	0	8	1.8
MSV030-4	1.078	3	6	10	4	2	0	12	1.8
AF5040-8	1.082	2	7	5	6	4	1	8	2.2
USPB/SFA TRIAL BRUISE SAMPLES									
AF5429-3	1.073	9	14	1	1	0	0	36	0.8

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Table 11

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2018 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
NDTX081648CB-13W	1.076	8	11	1	2	2	0	33	1.1
NDA081453CAB-2C	1.076	7	11	3	2	1	1	28	1.3
W9968-5	1.080	6	9	7	3	0	0	24	1.3
ND7519-4 (bruise bag has -1)	1.082	4	9	6	5	0	0	17	1.5
Mackinaw (MSX540-4)	1.084	3	8	7	4	2	1	12	1.9
Snowden	**1.078**	**0**	**5**	**7**	**8**	**3**	**1**	**0**	**2.5**
Lamoka	**1.077**	**2**	**4**	**4**	**9**	**4**	**2**	**8**	**2.6**
MSW044-1	1.085	0	4	7	6	6	2	0	2.8
NY162	1.075	2	0	5	8	5	5	8	3.2
MSV030-4	1.078	0	1	2	6	9	8	0	3.8
AF5040-8	1.082	1	0	3	2	3	16	4	4.2

* Thirteen to twenty-five (dependent on the number of replications used) 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 10/26 & 11/1&2/2018.
The table is presented in ascending order of average number of spots per tuber.

Funding: Federal Grant, MPIC and Potatoes USA/SNAC

2018 On-Farm Potato Variety Trials

Chris Long, Trina Zavislan, John Calogero, Dr. Dave Douches
Cooperators: James DeDecker, (Presque Isle Co.), Monica Jean (Delta Co.)

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 2018, we conducted 37 on-farm potato variety trials with 16 growers in 11 counties.

Processing trial cooperators were: 4-L Farms, Inc. (Allegan), Black Gold Farms (St. Joseph), County Line Farms (Allegan), Crawford Farms, Inc. (Montcalm), Hampton Potato Growers (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), Verbrigghe Farms (Delta), Walther Farms, Inc. (St. Joseph), and Wilk Farms (Presque Isle).

PROCEDURE

A. Processing Variety Trials

We evaluated 48 chip processing varieties in 2018. 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. 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 Sackett Potatoes, Sandyland Farms, and Walther 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 2018 annual report published by Potatoes USA.

C. Fresh Market Trials

Within the fresh market trials, we evaluated 100 primary entries (this does not include entries from Potatoes USA/NFPT trial) which included: 26 russet, 25 red, 27 yellow, 9 novelty, and 13 round white types. To evaluate selected table-stock lines, we used the following check varieties:
Red: Dark Red Norland
Round White: Onaway, Reba
Russet: GoldRush, Russet Norkotah, Silverton Russet
Yellow: 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, Yoder Farms, Lennard Ag. Co.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 2018 (Table 1) and evaluated these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Table 2). Below are six superior processing varieties from 2018.

MSZ096-3: This Michigan State University selection was evaluated only in the MSU Box Bin trial, and had the highest overall and US #1 yields in 2018 of 787 cwt/A and 731 cwt/A, respectively. It produced mainly A-sized tubers with 93% A size potatoes and 6% B-sized potatoes. It will be further evaluated across multiple locations in 2019. This variety had an average common scab rating of 1.5, higher than the trial average of 0.8. It had no incidence of stem end defect, and had an off the farm chip color of 1.5 Compared to the trial average of 1.076, MSZ096-3 had a higher specific gravity of 1.081. It requires full season maturity and has smaller vines. Some flattened tubers were observed in 2018.

MSZ120-4: This variety had the second highest US #1 yield in the processing variety trial of 587 cwt/A. It had 90% US #1 tubers and no pickouts. The specific gravity was 1.086, higher than average, 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 20% vascular discoloration. MSZ120-4 is a medium-late maturing plant with smaller vines.

BNC182-5: This Maryland variety had a high yield of 453 cwt/A US #1 tubers. It had a larger size profile with 7% oversize tubers. BNC182-5 had a lower than average specific gravity of 1.073, and an off the farm chip score of 1.3. It had some internal defects, including 12% vascular discoloration and 12% hollow heart. This variety will be further evaluated for fresh market use only across multiple locations in 2019.

Niagara (NY152): This recently named Cornell variety was evaluated at nine locations in 2018. It had 87% US #1 tubers and a US#1 yield of 421 cwt/A. This variety had an average specific gravity of 1.076 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 0.8. The tubers were uniformly shaped and round.

Mackinaw (MSX540-4): This Michigan State University variety was planted at fourteen locations, and had an average yield of 279 cwt/A US #1 tubers, significantly lower than in previous years. It had a high specific gravity of 1.079, and an off the farm chip score of 1.2. It had a low incidence of internal defects except for 11% 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.

MSZ219-14: This variety has been selected for the NexGen trial, and was evaluated at three locations in 2018. It had a high US#1 yield of 408 cwt/A and 89% A-sized tubers. It had a higher incidence of hollow heart than the trial average. This variety has medium maturity and produces moderately sized vines.

B. Potatoes USA/SNAC Int. Chip Trial

In 2018, 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 (Tables 7A and B).

The varieties with the highest US#1 yields were MSV030-4, W9968-5, and AF5429-3, with yields ranging from 500 cwt/A to 476 cwt/A. AF5429-3 had the highest percent of US #1 tubers at 91%, while MSW044-1 had the lowest at 67%. The average specific gravity of the trial was 1.079 (Table 3). Minimal brown spot, hollow heart, and brown center were observed in 2018. However all varieties displayed at least 3% vascular discoloration, with 27% incidence in W9968-5 (Table 4). Samples collected on October 16th were processed by Herr's Foods, Inc. on October 29th. ND7519-1 had the lowest SFA chip color, and was ranked first by Herr's for overall chip quality. MSX540-4 and MSV030-4 were also ranked highly, while AF5040-8 and NDTX081648CB-13W were ranked last in the trial (Table 5). Black spot bruise assessments demonstrated that AF5429-3, NDTX081648CB-13W, and W9968-5 were most resistant to black spot bruising, while MSV030-4 and AF5040-8 were most susceptible (Table 6).

C. Fresh Market and Variety Trial Results

We recorded general descriptions, pedigrees, and scab ratings for all fresh market varieties evaluated in 2018 (Table 8) and assessed these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Tables 9 and 10). Below are top performing russet, yellow, red, white, and novelty fresh pack varieties.

Russets

Castle Russet: This variety was evaluated at two locations in 2018, and will be planted across multiple locations in both strip trials and bulk plantings in 2019. It had the highest US#1 and total yield of all trial varieties, 519 and 608 cwt/A, respectively. It had a very high incidence of hollow heart, 75%, but other internal defects were below the trial average.

Caribou Russet: This University of Maine variety had the fourth highest US#1 trial yield at 459 cwt/A. It had a medium russeted skin type and a larger tuber size profile. This medium maturing variety is resistant to common scab and has a vigorous vine type. It had a specific gravity of 1.073, at the trial average, and low incidence of hollow heart, vascular discoloration, brown center. However, it had 22% internal brown spot, well above the trial average of 4%.

A08433-4stoRUS: This Aberdeen, Idaho variety also had a high yield of 499 cwt/A with 75% US #1 tubers. It had a specific gravity of 1.075 and a common scab rating of 0.2. This full season variety had a moderately vigorous vine, and internal defects below the trial average. A08433-4stoRUS has multiple disease resistances including PVY, *Verticillium* Wilt, Early Blight, and tuber Late Blight.

A07061-6RUS: This Aberdeen, Idaho variety was evaluated at eleven locations in 2018. It had a high US#1 yield of 440 cwt/A, and a smaller tuber size profile with 13% B-sized tubers. This variety had a specific gravity of 1.073 and excellent internal quality, with 6% vascular discoloration. It had a higher than average common scab rating of 1.3 and a medium vine maturity.

Yellow Flesh

Actrice: This yellow-fleshed variety had the highest total and US#1 trial yield of 782 and 716 cwt/A, respectively. It produced 91% A-sized tubers and had a lower specific gravity of 1.057. Internal quality was good except for 20% vascular discoloration. This variety had a common scab rating of 0.3, and tended to produce misshapen pickouts.

Queen Anne: This variety has a consistent attractive appearance with a smooth skin finish and medium yellow flesh. With a US#1 yield of 278 and total yield of 430 cwt/A, this variety had a smaller size profile with 39% B-sized tubers. It had high ratings for both skin waxiness and yellow flesh color.

Soraya: This Norika selection a high yield of 330 cwt/A in 2018 with 64% US#1 potatoes. It had a specific gravity of 1.059, lower than the trial average of 1.069, and medium vine vigor and maturity. It had good internal quality, with internal defects below the trial average, and a common scab rating of 0.2.

Jelly: This SunRain variety had the second highest US #1 yield of 462 cwt/A with 77% US #1 tubers. At 1.064, it had a lower than average specific gravity, and a common scab rating of 0.5. Jelly had a high incidence of vascular discoloration at 70%, well above the trial average of 13%. This full season variety had oval to oblong tubers.

MSX156-1Y: This Michigan selection also had a high yield of 444 cwt/A US#1 tubers. It had excellent internal quality and an average common scab rating. While the tubers were an attractive round shape, the variety had some netted skin and alligator hide.

Red Skin

Cerata: This Stet Holland variety was the highest yielding variety in the 2018 red skin potato trial with a US #1 yield of 439 cwt/A. It was evaluated at nine locations in 2018, and had 75% US #1 tubers. Cerata had a specific gravity of 1.063, slightly lower than the trial average of 1.064. It had good internal quality with defects at or below the trial average. This full season variety had a common scab rating of 0.9 and slight skin flaking.

W8405-1R: This University of Wisconsin variety had a high US #1 yield of 334 cwt/A and a specific gravity of 1.060. Its internal quality was acceptable, with 10% vascular discoloration and 9% internal brown spot. This variety had an oval tuber type, very vigorous vine, and medium maturity.

W8890-1R: This mid-season maturing Wisconsin variety produced attractive, uniform tubers with deep red skin. It had a US#1 yield of 313 cwt/A, slightly above the trial average of 245 cwt/A. W8890-1R had a smaller size profile with 24% B size tubers. It had a higher than average incidence of vascular discoloration at 25%.

CO98012-5R: This Colorado selection has an attractive tuber type and skin finish, but is scab susceptible. It had an above average yield of 311 cwt/A and very good internal quality. The common scab score of 1.9 was higher than the trial average of 0.6.

Round White

White Beauty: This variety was the highest yielding round white potato in 2018. Evaluated at one location, it had a total yield of 608 cwt/A and US#1 yield of 562 cwt/Q. It had no common scab, and a slightly higher than average specific gravity of 1.071. White beauty was late to mature and produced vigorous vines.

MSY111-1: This Michigan State University selection had an average yield of 384 cwt/A of US#1 tubers. This variety produced 76% A-sized tubers, which were round with netted skin. It had good internal quality with 10% vascular discoloration. This mid-season variety had a common scab rating of 0.8.

MSX497-6: This variety produced larger tubers, with 91% A-sized tuber in 2018. It had good internal quality, a common scab score of 1.7, and mid-season maturity. MSX497-6 had an average yield of 375 cwt/A.

Nadine: While this variety had a lower yield of 305 cwt/A US#1 tubers, it had a smaller size profile and produced 22% B-sized tubers. It had no internal defects in 2018, and a common scab score of 0.5. It had bright, shiny skin and an attractive appearance.

Novelty

MSV443-1PP: This Michigan selection had purple skin and flesh, and was the highest yielding novelty variety in 2018. With a total yield of 374 cwt/A, this variety produced an even split of A and B-sized potatoes. It had no internal defects and a common scab score of 0.3. The purple skin was a uniform dark color, but moderate silver scurf was observed.

MSW148-1P: This variety had purple skin and white flesh, and was evaluated at seven locations in 2018. It had the second highest total yield of 385 cwt/A and 69% US#1 tubers. It had good internal quality, but moderate silver scurf with a rating of 2.5, above the trial average of 1.5.

Table 1. 2018 Chip Processing Variety Descriptions

Entry	Pedigree	2018 Scab Rating*	Characteristics
Atlantic	Wauseon x B5141-6 (Lenape)	1.0	High yield, early maturing, high incidence of hollow heart and internal brown spot, high specific gravity, more oversize tubers than trial average
Hodag (W5955-1)	Pike x Dakota Pearl	0.6	Average yield, high specific gravity, size profile similar to Atlantic, management should be adjusted because this variety tends to produce large tubers, long storage potential with common scab resistance
Lamoka (NY139)	NY120 x NY115	0.7	Average 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	0.9	Average yield with early to mid-season maturity, excellent chip-processing quality and long storage potential, scab tolerance and specific gravity similar to Snowden, uniform round tubers with shallow eyes and heavy netted skin, some compressed tubers apical to stem
Mackinaw (MSX540-4)	Saginaw Chipper x Lamoka	0.8	Average yield with high specific gravity and high percentage of A-sized tubers, mid to late-season maturity, long-term chip-processing quality with resistance to PVY and late blight and tolerance to common scab, currently in Fast Track program

(2018 Processing Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
MegaChip	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
Niagara (NY152)	B38-14 x Marcy	0.8	High yield potential, medium specific gravity, excellent long-term storage chip quality, tolerance to common scab,
Pike (NYE55-35)	Allegany x Atlantic	0.6	Average yield, early to mid-season maturity, small tuber size profile, early storage, some internal defects, medium specific gravity
Snowden (W855)	B5141-6 x Wischip	1.6	High yield, medium-late maturity, mid-season storage, reconditions well in storage, medium to high specific gravity
AC00206-2W	AC87340-2 x ND2627-10	1.4	Common scab susceptible, early to mid-season maturity, lower specific gravity
AC03452-2W	A98423-1C x COA96141-2C	1.3	High yield potential, high percentage of US #1 tubers, susceptibility to vascular discoloration
AC05153-1W	A91814-5 x Chipeta	1.0	Lower yield, smaller tuber size profile, good internal quality, low stem end defect
AF5429-3	Dakota Pearl x NY140	2.5	High yield potential and percentage of US #1 tubers, round tuber type, average specific gravity

(2018 Processing Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
AF5040-8	AF2376-5 x Lamoka	0.8	High yield potential, high specific gravity, medium maturing, vigorous vines, pale yellow flesh, round to oblong shape, common scab susceptible
BNC182-5	Tacna x B0766-3	0.3	High yield potential, average specific gravity, good OTF chip quality
B2869-29	B0564-8 x B1316-5	0.7	Average yield potential, higher specific gravity,
B2904-2	B1873-6 x Coastal Chip	0.7	Above average yield potential, susceptible to vascular discoloration and hollow heart
BNC311-4	BNC41-7 x NCB2489-5	0.7	Average yield potential, susceptible to heat knobs, good internal quality, oval to oblong tuber type, acceptable OTF chip quality
CO02033-1W	A91790-13W x S440	0.8	Smaller tuber size profile, above average specific gravity, mid-season maturity
CO02321-4W	NY115 x BC0894-2W	1.5	Average yield, good OTF chip quality, common scab susceptibility
CO10076-4W	CO03243-3W x CO02024-9W	0.0	Above average yield, susceptible to vascular discoloration, full season maturity
MSV030-4	Beacon Chipper x MSG227-2	0.4	High yield and specific gravity, uniform round tuber type, good OTF chip quality

(2018 Processing Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
MSV111-2	MSJ316-A x MSN105-1	0.1	Smaller size profile, lower specific gravity, less susceptible to common scab, rougher skin
MSV498-1	Snowden x MSQ283-2	0.1	Average yield, high percentage US#1 tubers, average internal quality, less susceptible to common scab
MSW044-1	Kalkaska x Lamoka	0.3	High specific gravity, average yield, good internal quality, bright skin, uniform round tuber type
MSW485-2	MSQ070-1 x MSR156-7	0.4	High yielding with high specific gravity, full-season maturity, excellent chip-processing quality out of the field and long-term storage, resistance to late-blight and common scab tolerant
MSY156-2	MSK061-4 x Kalkaska	0.0	Good OTF chip quality and internal quality, above average yield
MSZ022-7	Kalkaska x Tundra	0.0	Average yield potential, full season maturity, SED observed in 2018
MSZ022-16	Kalkaska x Tundra	0.2	Average yield and specific gravity, susceptible to internal brown spot, less susceptible to common scab
MSZ052-2	Pike x MSR127-2	0.6	High yield and specific gravity, susceptible to internal brown spot, high percentage A sized tubers

(2018 Processing Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
MSZ062-10	MSR127-2 x McBride	0.2	High yield, average specific gravity, susceptible to vascular discoloration
MSZ096-3	Boulder x MSR127-2	1.5	Highest yielding variety in 2018, above average specific gravity, good internal quality
MSZ118-8	Kalkaska x Lenape	0.4	Average yield and internal quality, at trial average for common scab, internal defects, vigor, and maturity
MSZ120-4	Kalkaska x MSQ086-3	0.0	High yield, no common scab observed in 2018, 90% US #1 tubers, bright skin, full season maturity
MSZ219-1	Saginaw Chipper x MSR127-2	0.5	Scab, PVY and late-blight resistant with high specific gravity, smooth and round tubers, in NCPT and Fast Track
MSZ219-13	Saginaw Chipper x MSR127-2	0.2	High yield potential, good chip color, some VD in 2017, no common scab observed 2017.
MSZ219-14	Saginaw Chipper x MSR127-2	0.2	High specific gravity, high yield potential with a high percentage of A-sized tubers, mid to late season maturity, long-term chip-processing quality with resistance to common scab, late blight, and PVY, in NCPT and Fast Track
MSZ219-46	Saginaw Chipper x MSR127-2	0.2	Lower yield potential, some VD observed in 2017, good chip color

(2018 Processing Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
MSZ222-19	MSR127-2 x Tundra	0.1	Average yield, deeper apical eyes, less susceptible to common scab
MSZ242-7	MSR169-8Y x MSU383-A	0.2	Above average yield and specific gravity, good internal quality, medium to full season maturity
MSZ242-9	MSR169-8Y x MSU383-A	0.4	Average yield potential, high specific gravity, susceptible to internal brown spot
MSZ242-13	MSR169-8Y x MSU383-A	0.3	Average yield potential, good internal quality, mid-season maturity
MSZ248-10	Snowden x MSV229-2	1.5	Good OTF chip quality, no internal defects observed in 2018, average yield potential
NDA081453CAB-2C	Dakota Diamond x ND039173CAB-22	0.0	Larger tuber size profile, good internal quality, no common scab observed in 2018
NDTX081648CB-13W	ND8456-1 x ND7377CB-1	1.0	Low yield, smaller tuber size profile, susceptible to vascular discoloration
ND7519-1	ND3828-15 x W1353	0.7	Above average yield potential, susceptible to vascular discoloration
NY162	NYE106-2 x NYE48-2	1.1	High yield potential, low internal defects, medium specific gravity, moderate common scab resistance
W9968-5	Fasan x Nicolet	0.8	Average yield potential, acceptable OTF chip color, good internal quality, mid-season maturity

*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 various potato breeding programs and updated by Potato Outreach Program following evaluations at various trial locations throughout Michigan.

Table 2. 2018 Michigan Statewide Chip Processing Potato Variety Trials
Overall Averages- Fourteen 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
MSZ096-3[j]	731	787	93	6	93	0	1	1.081	1.5	0	10	0	0	1.5	-	1.5	5.0	some flattened tubers
MSZ120-4[j]	530	587	90	10	90	0	0	1.086	1.0	0	20	0	0	0.0	-	1.0	4.5	bright skin
MSZ052-2[ghimn]	524	557	95	3	85	10	2	1.070	1.3	0	5	36	4	0.6	0.3	3.2	3.0	uniform round tuber type, darker netted skin
Atlantic[begm]	**485**	**549**	**89**	**2**	**74**	**15**	**9**	**1.078**	**1.0**	**35**	**3**	**25**	**0**	**1.0**	**0.4**	**2.0**	**4.1**	**sl alligator hide, GC and misshapen POs**
AC03452-2W[acefhijm]	480	573	84	11	82	2	5	1.065	1.1	5	23	1	0	1.3	0.2	2.9	3.4	misshapen POs, light skin finish
AF5429-3[l]	476	520	91	8	90	1	1	1.073	1.0	7	10	0	3	2.5	0.5	3.0	3.0	attractive round tuber type
MSW485-2[abcdefghijmn]	473	523	90	8	87	3	2	1.079	1.4	10	23	8	3	0.4	1.0	2.6	4.2	sl alligator hide, attractive bright white flesh
MSZ062-10[abefghijmn]	462	507	91	5	87	4	4	1.076	1.4	3	18	1	3	0.2	0.7	2.5	2.9	uniform skin finish, sl alligator hide
BNC182-5[abcegimn]	453	503	91	6	84	7	3	1.073	1.3	13	12	4	1	0.3	1.0	2.7	4.1	mod skin flaking, sl alligator hide
MSV030-4[abcdefghijklmn]	434	497	88	9	86	2	3	1.081	1.5	1	15	1	0	0.4	0.4	2.6	3.3	uniform round tuber type, netted skin, sl alligator hide
CO10076-4W[j]	432	515	84	16	84	0	0	1.074	1.5	0	40	0	0	0.0	-	2.5	3.5	
Snowden[bcdefhijlmn]	**431**	**477**	**91**	**7**	**86**	**5**	**2**	**1.077**	**1.2**	**6**	**19**	**5**	**0**	**1.6**	**0.5**	**2.7**	**3.0**	**netted skin, tr alligator hide, misshapen POs**
NY162[abcfhijlmn]	427	478	88	8	85	3	4	1.076	1.2	2	6	3	1	1.1	0.4	2.1	3.1	sl alligator hide, points and bottlenecking in POs
B2904-2[bcefghijmn]	425	499	86	6	82	4	8	1.077	1.2	24	23	1	1	0.7	0.7	2.5	3.3	mod GC, deep stem ends, bottlenecking and misshapen POs
Niagara (NY152)[acfdkhijn]	421	485	87	11	87	0	2	1.076	1.4	14	12	0	1	0.8	0.3	2.3	2.8	uniform round tuber type, sl alligator hide
Mega Chip[h]	409	458	90	3	88	2	7	1.081	1.0	0	40	0	0	0.0	0.4	3.0	2.0	mod alligator hide, misshapen POs
MSZ219-14[hjn]	408	444	90	8	89	1	2	1.073	1.2	24	10	4	2	0.2	0.9	2.5	3.3	sl alligator hide, GC in POs
MSZ242-7[ejm]	406	468	86	7	79	7	7	1.085	1.3	0	10	3	0	0.2	0.5	1.8	3.8	tr alligator hide, knobs and misshapen POs
MSY156-2[j]	404	452	90	10	90	0	0	1.079	1.0	0	10	0	0	0.0	-	1.5	3.0	bright skin, attractive round tuber profile
ND7519-1[l]	394	478	82	18	82	0	0	1.082	2.0	0	23	0	0	0.7	0.2	2.5	3.5	tr greening and alligator hide, smooth skin
MSZ219-46[acefghijmn]	389	452	86	4	84	2	10	1.069	1.7	0	11	0	0	0.2	1.2	2.3	2.9	oblong tuber type, mod alligator hide
MSW044-1[abcdefghijlmn]	383	453	85	14	83	2	1	1.081	1.2	7	10	3	1	0.3	0.4	2.5	3.4	bright skin, uniform round tuber type
B2869-29[bcefghijmn]	379	445	85	12	84	1	3	1.081	1.2	1	11	2	2	0.7	0.5	2.6	2.9	sl alligator hide, misshapen POs
MSZ222-19[acefghijmn]	372	433	86	8	82	4	6	1.077	1.4	13	1	3	0	0.1	0.4	2.5	3.1	mod alligator hide, deep apical eyes, GC in POs
MSZ022-16[hin]	369	428	86	9	85	1	5	1.074	1.5	4	9	39	6	0.2	0.6	3.1	3.1	sl alligator hide, mod skinning, misshapen POs
MSZ118-8[abefhimn]	367	450	82	9	74	8	9	1.070	1.3	5	7	13	9	0.4	0.7	2.3	3.4	sl alligator hide, misshapen POs
W9968-5[abcefghijlmn]	367	461	79	7	74	5	14	1.080	1.3	10	12	8	2	0.8	1.2	2.3	3.7	netted skin, many misshapen tubers, tr alligator hide
MSZ242-9[bcgijn]	365	440	82	9	77	5	9	1.080	1.2	0	7	23	0	0.4	0.4	2.4	3.3	sl alligator hide, deep apical eyes, GC in POs
MSV498-1[gjn]	358	390	92	6	90	2	2	1.067	1.2	7	14	0	2	0.1	1.2	2.4	3.4	netted skin, tr alligator hide, oblong tubers
MSZ219-13[abcefhijn]	358	387	92	4	89	3	4	1.073	1.6	9	11	1	1	0.2	0.5	2.2	4.0	heavy netted skin type, tr alligator hide, GC in POs
BNC311-4[bcegijm]	357	458	78	10	74	4	12	1.072	1.0	7	1	0	0	0.7	0.6	2.5	3.4	oval to oblong tuber type, GC and apical heat knobs
CO02321-4W[chijn]	354	409	86	12	86	0	2	1.080	1.1	11	11	0	1	1.5	0.6	3.4	2.7	mod alligator hide, greening in POs
MSZ242-13[acefhijmn]	353	401	87	6	84	3	7	1.087	1.6	6	3	1	0	0.3	0.5	2.5	3.5	tr GC, netted skin type
MSZ248-10[j]	346	385	90	9	90	0	1	1.079	1.0	0	0	0	0	1.5	-	1.5	1.5	
MSV111-2[jn]	341	442	77	21	77	0	2	1.066	1.5	2	13	8	0	0.1	1.7	2.3	3.6	misshapen POs, sl alligator hide
Lamoka[abcfhijl]	**334**	**383**	**87**	**7**	**82**	**5**	**6**	**1.077**	**1.3**	**4**	**23**	**1**	**0**	**0.7**	**0.5**	**2.3**	**2.8**	**pear shaped and misshapen POs**
AF5040-8[acdefghijlmn]	315	378	82	13	80	2	5	1.081	1.5	3	18	0	0	0.8	0.5	2.9	2.7	tr alligator hide, cream colored flesh, misshapen POs
Pike[cdehi]	**311**	**364**	**84**	**12**	**84**	**0**	**4**	**1.079**	**1.1**	**8**	**18**	**2**	**0**	**0.6**	**0.4**	**2.6**	**3.0**	**bright skin finish, tr alligator hide**
Manistee[acdefhijn]	307	345	89	8	89	0	3	1.076	1.3	10	10	9	1	0.9	0.4	2.6	2.3	flat stem end, mod skinning
NDA081453CAB-2C[l]	298	337	89	9	89	0	2	1.076	1.0	0	10	3	17	0.0	0.4	2.5	2.5	larger tuber size profile, light skin
CO02033-1W[acefghijmn]	294	418	70	19	70	0	11	1.081	1.2	11	16	1	1	0.8	0.5	2.9	3.2	smaller uniform tuber size profile, sl alligator hide
MSZ219-1[acfijn]	279	316	81	12	80	1	7	1.073	1.7	1	11	15	3	0.5	0.7	2.8	2.8	sl alligator hide, darker netted skin
Mackinaw (MSX540-4)[abcdefghijklmn]	279	344	80	11	79	1	9	1.079	1.2	4	11	0	0	0.6	0.6	1.9	3.3	sl alligator hide, attractive tuber shape and size
AC00206-2W[bcefghijmn]	262	343	75	19	73	2	6	1.068	1.1	12	3	9	0	1.4	0.2	2.9	2.6	mod alligator hide, sl skinning
Hodag (W5955-1)[cdikn]	250	295	85	6	80	5	9	1.075	1.5	28	11	6	7	0.6	0.7	2.4	3.3	sl skin flaking, GC in POs
NDTX081648CB-13W[l]	230	311	73	25	73	0	2	1.076	1.5	3	23	0	3	1.0	0.6	3.0	2.5	some tubers with pink eyes
AC05153-1W[acfghijmn]	203	315	64	33	64	0	3	1.072	1.3	0	3	0	0	1.0	0.2	3.0	2.0	tr alligator hide, small uniform tuber type
MSZ022-7[n]	182	281	65	18	65	0	17	1.064	1.5	0	7	43	0	0.0	0.3	3.3	3.3	severe GC, mod alligator hide
MEAN	**379**	**442**	**85**	**10**	**82**	**3**	**5**	**1.076**	**1.3**	**6**	**13**	**6**	**2**	**0.6**	**0.6**	**2.5**	**3.2**	

2018 CHIP VARIETY TRIAL SITES

[a]4-L Farms, Allegan County
[b]Black Gold Fresh Trial, St. Joseph County
[c]County Line Farms, Allegan County
[d]Crawford Farms, Montcalm County
[e]Hampton Farms Fresh Trial, Bay County
[f]Hampton Farms, Bay County
[g]Lennard Ag. Co. Fresh Trial, St. Joseph County
[h]Lennard Ag. Co, St. Joseph County
[i]Main Farms, Montcalm County
[j]MSU Box Bin Trial, Montcalm County
[k]Sandyland Farms, Montcalm County
[l]Sandyland Farms SNAC Trial, Montcalm County
[m]Walther Farms Fresh Trial, St. Joseph County
[n]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

[3]OUT OF

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

[4]RAW

(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

[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

[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*, Specific Gravity									
	Yield (cwt/A)		Percent Size Distribution						
Entry	US#1	TOTAL	US#1	Small	Mid-Size	Large	Culls	Specific Gravity	
MSV030-4	500[a]	613	81	18	81	0	1	1.078	
W9968-5	488[ab]	567	86	11	86	0	3	1.080	
AF5429-3	476[ab]	520	91	8	90	1	1	1.073	
Lamoka	**411[abc]**	**471**	**87**	**10**	**87**	**0**	**3**	**1.077**	
AF5040-8	409[abc]	478	86	12	86	0	2	1.082	
NY162	400[abc]	468	85	12	85	0	3	1.075	
Snowden	**395[abc]**	**446**	**89**	**11**	**89**	**0**	**0**	**1.078**	
ND7519-4	394[abc]	478	82	18	82	0	0	1.082	
MSW044-1	367[abc]	545	67	33	67	0	0	1.085	
MSX540-4	354[bcd]	452	78	21	78	0	1	1.084	
NDA081453CAB-2C	298[cd]	337	89	9	89	0	2	1.076	
NDTX081648CB-13W	230[d]	311	73	25	73	0	2	1.076	
MEAN	**394**	**474**	**83**	**16**	**83**	**0**	**2**	**1.079**	
ANOVA p-value	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**0.0023**	**0.0030**	**<.0001**	
LSD	**78.0**	**84.7**	**4.3**	**3.9**	**4.3**	**0.5**	**1.7**	**0.004**	

*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. Sandyland Farms, Howard City, Michigan.				
	Raw Tuber Quality[1] (%)			
Entry	HH	VD	IBS	BC
MSV030-4	0	23	0	0
W9968-5	0	27	0	3
AF5429-3	7	10	0	3
Lamoka	**0**	**57**	**0**	**0**
AF5040-8	0	10	0	0
NY162	0	3	0	0
Snowden	**0**	**20**	**0**	**0**
ND7519-4	0	23	0	0
MSW044-1	0	10	0	3
MSX540-4	0	17	0	0
NDA081453CAB-2C	0	10	3	17
NDTX081648CB-13W	3	23	0	3
MEAN	**1**	**19**	**0**	**3**
ANOVA P-value	**0.0412**	**0.0004**	0.4744	**0.0006**
LSD	**4.0**	**17.8**	-	**6.3**

[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 2018 SNAC Trial at Sandyland Farms

Rank	Entry	SFA[2] Color	Specific Gravity	Percent Chip Defects[3] Internal	External	Total
1	ND7519-1	2.0	1.072	10.8	5.1	15.9
2	**Lamoka**	**3.0**	**1.072**	**13.1**	**6.8**	**19.9**
3	MSX540-4	3.0	1.083	17.7	16.1	33.8
4	MSV030-4	3.0	1.077	13.8	10.1	23.9
5	**Snowden**	**3.5**	**1.072**	**20.2**	**17.1**	**37.3**
6	NDA081453CAB-2C	3.5	1.082	21.8	15.1	36.9
7	MSW044-1	3.5	1.085	24.4	4.2	28.6
8	W9968-5	4.0	1.077	54.9	4.3	59.2
9	NY162	4.0	1.077	34.9	19.4	54.3
10	AF5429-3	3.5	1.074	38.0	24.1	62.1
11	AF5040-8	4.0	1.082	43.4	17.8	61.2
12	NDTX081648CB-13W	4.5	1.076	54.9	7.8	62.7

[1]Samples collected October 16th and processed by Herr Foods, Inc., Nottingham, PA on October 29th, 2017.

[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 2018 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
AF4529-3	14	7	1	2	1	0	25	56	0.8	9	14	1	1	0	0	25	36	0.8
NDTX0981648CB-13W	18	5	1	0	0	0	24	75	0.3	8	11	1	2	2	0	24	33	1.1
W9968-5	15	6	4	0	0	0	25	60	0.6	6	9	7	3	0	0	25	24	1.3
NDA081453CAB-2C	15	9	1	0	0	0	25	60	0.4	7	11	3	2	1	1	25	28	1.3
ND7519-4	17	8	0	0	0	0	25	68	0.3	4	9	6	5	0	0	24	17	1.5
MSX540-4	18	7	0	0	0	0	25	72	0.3	3	8	7	4	2	1	25	12	1.9
Snowden	**10**	**15**	**0**	**0**	**0**	**0**	**25**	**40**	**0.6**	**0**	**5**	**7**	**8**	**3**	**1**	24	**0**	**2.5**
Lamoka	**11**	**11**	**3**	**0**	**0**	**0**	**25**	**44**	**0.7**	**2**	**4**	**4**	**9**	**4**	**2**	25	**8**	**2.6**
MSW044-1	9	9	5	2	0	0	25	36	1.0	0	4	7	6	6	2	25	0	2.8
NY162	2	5	12	5	0	0	24	8	1.8	2	0	5	8	5	5	25	8	3.2
MSV030-4	3	6	10	4	2	0	25	12	1.8	0	1	2	6	9	8	26	0	3.8
AF5040-8	2	7	5	6	4	1	25	8	2.2	1	0	3	2	3	16	25	4	4.2

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

[2]Tuber samples collected at harvest, held at 50ºF for 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 2018 SNAC Trial at Sandyland Farms, Taken on 8/13/2018								
	Specific	Glucose[1]	Sucrose[2]	Canopy		Number of		Average[5] Tuber
Entry	Gravity	%	Rating	Rating[3]	Uniform.[4]	Hills	Stems	Weight
MSV030-4	1.081	0.008	0.548	100	100	2	10	2.68
W9968-5	1.084	0.006	0.578	100	100	3	12	2.74
AF5429-3	1.073	0.003	1.580	100	100	4	19	2.53
Lamoka	**1.077**	**0.002**	**0.694**	**100**	**100**	**4**	**18**	**3.93**
AF5040-8	1.079	0.002	0.705	100	100	4	16	2.44
NY162	1.075	0.002	0.346	100	100	4	14	3.36
Snowden	**1.080**	**0.002**	**0.525**	**100**	**100**	**4**	**15**	**3.48**
ND7519-4	1.090	0.004	0.796	100	100	3	14	3.00
MSW044-1	1.080	0.005	3.483	100	100	4	22	2.61
MSX540-4	1.088	0.002	0.454	100	100	4	18	2.52
NDA081453CAB-2C	1.076	0.004	1.873	75	100	4	15	3.27
NDTX081648CB-13W	1.081	0.032	0.918	100	100	6	25	3.10

Table 7B. Pre-Harvest Panel for the 2018 SNAC Trial at Sandyland Farms, Taken on 8/27/2018								
	Specific	Glucose[1]	Sucrose[2]	Canopy		Number of		Average[5] Tuber
Entry	Gravity	%	Rating	Rating[3]	Uniform.[4]	Hills	Stems	Weight
MSV030-4	1.084	0.002	0.505	75	100	3	17	4.33
W9968-5	1.079	0.003	0.823	75	100	5	17	2.72
AF5429-3	1.077	0.002	1.204	75	100	3	14	3.36
Lamoka	**1.081**	**0.002**	**0.667**	**75**	**100**	**4**	**12**	**5.21**
AF5040-8	1.080	0.002	0.484	100	100	4	14	3.97
NY162	1.064	0.002	0.357	75	100	4	10	3.87
Snowden	**1.081**	**0.002**	**0.617**	**75**	**100**	**4**	**18**	**3.62**
ND7519-4	1.082	0.002	0.821	50	100	4	21	3.17
MSW044-1	1.089	0.003	1.759	75	100	3	12	3.13
MSX540-4	1.093	0.003	0.490	75	100	3	18	3.59
NDA081453CAB-2C	1.076	0.003	1.180	75	100	5	28	4.16
NDTX081648CB-13W	1.073	0.014	0.772	75	100	8	33	2.97

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

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

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

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

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

Table 8. 2018 Russet and Tablestock Variety Descriptions

Russet Variety Descriptions

Entry	Pedigree	2018 Scab Rating*	Characteristics
Caribou Russet (AF3362-1Rus)	Reeves Kingpin x Silverton Russet	0.2	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 2018, PVY susceptible, below average tuber set
Castle Russet (POR06V12-3)	PA00V6-4 x PA01N22-1	0.0	Long, full season russet with dual-purpose potential, resistant to PVY, Pecto., and corky ring spot, moderate dormancy, susceptible to foliar late blight. Highest yielding russet in 2018
GoldRush Russet (ND1538-1Rus)	ND450-3Rus x Lemhi Russet	0.0	Medium maturity, oblong-blocky to long tubers, bright white flesh, common scab resistance, average yield potential
Mountain Gem (A03158-2TERUS)	A98292-2 x A98104-4	0.0	High yield potential, common scab and tuber late blight resistance, medium maturity, nice dark russet skin type, blocky to long shape
Reveille Russet (ATX91137-1Rus)	Bannock Russet x A83343-12	0.3	Excellent yield potential, common scab tolerant, early bulking, nice uniform dark russeted skin with good general tuber appearance, occasional misshapen tubers observed, long dormancy
Russet Norkotah	ND9526-4Rus x ND9687-5Rus	0.2	Average yield, mid-season maturity, long to oblong tubers, heavy russet skin, low specific gravity

(2018 Russet Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
Silverton Russet (AC83064-6)	A76147-2 x A7875-5	0.3	High yield, oblong to long blocky tuber type, medium netted russet skin, masks PVY, medium to low specific gravity, PVY, Sencor & Linuron susceptibility
Vanguard (TX08352-5RUS)	TXA549-1Ru x AOTX98137-1Ru	0.1	Nice slightly blocky shape, medium size profile, medium vine vigor and maturity, semi-erect vines, average yield potential
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
A07061-6RUS	Clearwater Russet x Targhee Russet	0.9	Above average yield potential, good internal quality, full season maturity
A071012-4BFRUS	A85331-7 x A01054-4	0.5	Light russet skin, low tuber set with larger tuber size profile, susceptible to blackspot bruise and hollow heart, high specific gravity
A08433-4VRRUS	A02611-1 x AOND95249-1	0.2	Oblong tuber shape with medium russet skin, resistant to shatter bruise, tuber late blight, and common scab, high yield potential
AF5091-8RUS	AF4116-9 x AF4185-1	0.6	A mid-season russet with average yield potential, long to oblong tubers that tend to be large, resistance to blackspot bruise

(2018 Russet Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
AF5179-4RUS	A01601-4 x Highland Russet	1.1	Mid to late maturity, average yields and above average specific gravity, long to oblong tubers that tend to be large, resistance to verticillium wilt
AF5312-1RUS	A86102-6 x CO82142-4	0.3	Dark russet skin, good internal quality, smaller tuber size profile, resistant to tuber internal defects, early to mid-season maturity
AF5406-7RUS	Silverton Russet x A7816-14	0.2	Full season variety, average yield potential
CO05068-1RUS	AWN86514-2 x CO98009-3RU	0.2	Average yield potential, full season maturity, susceptible to hollow heart, higher specific gravity
CO07015-4RUS	Fortress Russet x AC00033-2RU	0.0	Early maturity, oblong tubers with medium russet skin, smaller tuber size profile with 40 percent B size tubers
CO07049-1RUS	AOA95155-7 x AC00594-4RU/Y	0.1	Medium maturity, small tuber size profile, good internal quality
CO09036-2RUS	AO98282-5 x CO03276-4RU	0.2	Average specific gravity, resistant to blackspot bruise, full season maturity
CO10087-4RUS	CO03367-1RU x CO99100-1RU	0.3	Early maturity, high specific gravity, larger tuber size profile, susceptible to hollow heart
CO10091-1RUS	CO03371-4RU x CO98067-7RU	0.6	Resistant to blackspot bruise, above average yield potential

(2018 Russet Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
CW08071-2RUS	Premier Russet x Canela Russet	0.5	Average to high yield potential, blocky shape, resistant to tuber internal defects
WAF10612-1RUS	W6260-1RUS x Silverton Russet	2.3	Average yield potential, excellent internal quality.
W10594-16RUS	Premier Russet x Freedom Russet	0.5	Light russet skin, medium maturity, average yield potential, good internal quality
W10612-8RUS	W6360-1RUS x Russet Norkotah	1.0	Mid-season maturity, hollow heart susceptible, above average yield potential

* 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.

2018 Yellow Flesh Variety Descriptions

Entry	Pedigree	2018 Scab Rating*	Characteristics
Actrice	Meijer Potato	0.3	High tuber set, resistant to leaf roll and several nematode species, highest yield in 2018
Alegria	Norika America, LLC	0.6	High yield potential, long-oval tuber shape, resistant to Ro1 Ro4 cyst nematodes, PVY, and leaf roll, average yield potential, good internal quality
Bonnata	Bernadette x RZ 95-6643	1.5	Oval shaper tubers, light yellow flesh, medium maturity, susceptible to vascular discoloration
Jazzy	Meijer Seed Potato Ltd.	0.7	Early maturity, small tuber size profile, light yellow flesh, waxy skin
Jelly	Sun Rain	0.5	High yield potential, oblong tubers, medium yellow flesh, medium to late maturity, resistant to common scab, PVY, Rhizoctonia, blackleg, and late blight
Lady Anna	Meijer Seed Potato Ltd.	1.2	Light yellow skin with yellow flesh, oblong shape, uniform, medium maturity, resistant to bruising and common scab, high specific gravity
Lady Claire	Meijer Seed Potato Ltd.	1.0	Round tuber size, light yellow flesh, smaller tuber size profile, some skin flaking
Lady Terra	Meijer Seed Potato Ltd.	1.2	High yield potential, uniform tubers, yellow skin with yellow flesh, medium to late maturity, resistant to common scab, adapted to a broad range of soil types

(2018 Yellow Flesh Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
Laperla	Solanum International	1.7	High tuber set, light yellow skin, oval tuber shape, early maturity, good internal quality
Orlena	Emergo x Laura (HZPC)	1.0	Oval to oblong shape, light yellow flesh, resistance to blackspot bruise, some pear shaped tubers
Queen Anne	Solanum International	0.4	Oval to oblong shape, yellow flesh, yellow skin, shallow eyes, medium to high scab resistance, PVY resistance and resistance to Ro1 and Ro4 nematodes, attractive appearance
Rock	Meijer Seed Potato Ltd.	2.0	High yield potential, suitable for table and french fries, yellow skin and yellow flesh, oval shape, prefers heavier soils, nematode resistance
Soraya	Norika America, LLC Marabeel x 1.307 120-93	0.2	High yield potential, late maturity, large oval-oblong tubers with yellow skin and yellow flesh, low specific gravity, resistant to common and powdery scab
Wendy	Norika America, LLC	1.3	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	1.3	Moderate yields, medium maturity, oval shaped with yellow-white skin and light yellow flesh, common scab susceptible
AC10376-1W/Y	Gala x Granola	1.6	High yield potential, full season maturity, resistance to blackspot bruise

(2018 Yellow Flesh Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
CO10064-1W/Y	CO00412-5W/Y x CO04099-4W/Y	1.4	B sized tuber profile, above average specific gravity, full season maturity
CO10097-2W/Y	CO04067-10W/Y x CO00412-5W/Y	2.9	Medium maturity, susceptible to vascular discoloration and common scab, average yield potential
CO10098-5W/Y	CO04099-3W/Y x CO04099- 3W/Y	2.5	High specific gravity, full season maturity, B sized tuber profile, common scab suceptible
CO10098-4W/Y	CO04099-3W/Y x CO04099- 3W/Y	2.5	Smaller tuber size, high specific gravity, good internal quality
MST252-1Y	MSL024-AY x MSL211-3	0.7	Average yield potential, good internal quality, light yellow skin color
MSV093-1Y	McBride x MSP408-14Y	0.5	Above average yield, susceptible to vascular discoloration, full season maturity
MSX156-1Y	MSI005-20Y x Boulder	1.1	High yield potential, good internal quality, medium yellow flesh color
MSX407-2Y	McBride x OP	0.3	Average yield potential, above average specific gravity, excellent internal quality
NY149	Yukon Gold x Keuka Gold	0.5	Mid to late season, slightly-textured skin and pink eyes, oval shape, medium yellow flesh, resistance to Ro1 cyst nematode, moderate common scab resistance
W9576-11Y	Dakota Pearl x Gala	0.3	Medium maturity, high yield potential, buff skin type, nice yellow flesh color

* 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.

2018 Red Skin Variety Descriptions

Entry	Pedigree	2018 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
Dark Red Norland	Redkote x ND626	0.4	Broadly adapted, low to moderate yields, early season maturity, smooth, oblong, slightly flattened tubers, common scab tolerant
Red Marker #2	-	0.9	Above average yield and specific gravity, good internal quality
AF4831-2R	ND028946B x ND8555-8R	1.5	Mid-season, bright red-skinned, white-fleshed variety with oblong tubers and small size profile, moderate common scab and verticillium resistance
AF5806-1	AF4614-2 x AF4566-4	0.0	Above average yield, excellent internal quality, average specific gravity
AF5831-2	Liberator x AF4566-4	0.5	Average yield, above average internal quality, some skinning observed in 2018
CO98012-5R	A79543-4R x AC91844-2	1.9	Attractive tuber size profile, dark red skin, susceptible to common scab
CO99076-6R	AC91848-1 x NDC5281-2R	0.0	Average specific gravity, good internal quality, medium red skin color and uniformity
CO99256-2R	NDC5281-2R x CO89097-2R	0.0	Susceptible to vascular discoloration, full season maturity

(2018 Red Skin Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
CO04159-1R	AC97521-1R/Y x CO99076-6R	1.5	Round tuber type, minimal silver scurf
CO06215-2R	CO99256-2R x CO01156-1R	0.0	Average yield potential, good internal quality, uniform red skin
COTX00104-6R	ND3574-5R x C086218-2	0.0	Uniform dark red skin color, average specific gravity
COTX02293-4R	NDC5281-2R x ND3574-5R	0.0	Average specific gravity, acceptable internal quality, lower than average yield
MSX569-1R	MSS002-2R x MSS544-1R	0.0	High percentage B size tubes, early maturity and small vine type, red pigmentation in vascular ring
NDAF102696C-5	ND049326C-2P x ND8555-8R	0.0	Attractive round tuber type, severe skinning, good internal tuber quality
NDAF11348B-1	ND060570B-1R x ND8555-8R	0.0	Early maturity, above average yield, good internal tuber quality
NDAF12129-6	ND7132-1R x ND4659-5R	0.0	Above average specific gravity, uniform medium red skin
NDAF12143-1	ND8555-8R x Dakota Jewel	0.0	Comparable to trial average in yield, size breakdown, gravity, and internal tuber quality
NDAF12198B-5	ND060570B-1R x AND00272-1R	1.5	Textured skin, less uniform color, good internal quality
NDTX071258BS-1R	ND039035B-9R x ND4659-5R	1.5	Attractive round tuber shape and skin finish, many pickouts observed in 2018

(2018 Red Skin Varieties cont.)

Entry	Pedigree	2018 Scab Rating*	Characteristics
NDTX4784-7R	ND3574-5R x ND2050-1R	0.0	Very early maturing with small vine, average yield potential
QSNDSU07-4R	-	2.0	Susceptible to internal brown spot, above average yield, smooth light red skin
W8405-1R	Kankan x W2303-9R	0.4	High yield potential, oval to oblong tuber type, mid-season maturity
W8890-1R	W2169-1R x Dakota Rose	1.3	Fresh market, dark red skin color and smaller size profile, attractive appearance
W8893-1R	W1101R X Dakota Rose	0.4	Average yield potential, lower specific gravity, mid-season maturity

* 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 various potato breeding programs and updated by Potato Outreach Program following evaluations at various trial locations throughout Michigan.

2018 Round White Variety Descriptions

Entry	Pedigree	2018 Scab Rating*	Characteristics
Harmony	Nadine x Stamina (Caithness)	0.0	Long dormancy, resistance to black dot and bruising, susceptible to dry rot, powdery scab, and silver scurf
Libertie	Harmony x Diva (Caithness)	0.0	Moderately resistant to bruising, dry rot, common and powdery scab, susceptible to PVY
Moonlight	1463.1 x V394 (New Zealand Institute for Crop and Food Research)	0.0	Good internal quality, moderate resistance to powdery scab, bacterial soft rot, and late blight, high percentage US #1 tubers
Nadine	Caithness	0.5	Resistance to potato cyst nematode, bright skin color and appearance
Onaway	USDAX96-56 x Katahdin	1.3	Early maturity, average specific gravity, used primarily out-of-the field for fresh market, minimal internal defects, not recommended for storage
Reba (NY 87)	Monona x Allegany	0.3	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
Rock	-	0.5	High specific gravity, mid-season maturity, good internal quality
Superior	USDA96-56 x M59.44	0.0	Early maturity, round to oblong tubers, deep eyes, resistant to net necrosis and common scab, susceptible to verticillium wilt, pressure bruise issues in long-term storage

(2018 Round White Varieties cont.)

Entry	Pedigree	2018 Common Scab Rating*	Characteristics
White Beauty	New Zealand	0.0	Resistant to PVY and common scab, susceptible to late blight, high yield
AF4138-8	SA9707-6 x AF1953-4	1.1	Susceptible to vascular discoloration, early maturity, moderate scab resistance, blackspot resistance, smaller size profile
AF5280-5	ND7799C-1 x ND860-2	0.3	Average yield potential, susceptible to vascular discoloration, early maturity
MSX497-6	MSQ131-A x MSL268-D	1.7	Bright skin appearance, uniform round tuber type, mid-season maturity
MSY111-1	MSQ086-3 x McBride	0.8	Round tuber shape, netted skin, mid-season maturity

* 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 various potato breeding programs and updated by Potato Outreach Program following evaluations at various trial locations throughout Michigan.

2018 Novelty Variety Descriptions

Entry	Pedigree	2018 Scab Rating*	Characteristics
AF5245-1P	Michigan Purple X Villeta Rose	0.5	Darker uniform skin color, larger vine type with earlier emergence
MSV235-2PY	Malinche x Colonial Purple	0.0	B-sized tuber profile, light yellow to cream flesh color
MSV443-1PP	MSU200-5PP x NDTX4271-5R	0.3	Mid to full season maturity, moderate silver scurf
MSW148-1P	Michigan Purple x MSP516-A	1.5	Common scab susceptible, good internal quality
MSW316-3PY	POR04PG6-3 x Colonial Purple	0.0	Very low specific gravity, light yellow flesh
MSX324-1P	MSN105-1 X Colonial Purple	0.9	Variable tuber shape and skin color, good internal quality
MSZ107-6PP	COMN07-W112BG1 x MSU200-5PP	0.5	Attractive smooth skin, almost all B-sized tubers
MSZ109-5RR	COMN07-W11BG1 X MSU200-5PP	0.5	Very small tuber size profile, all tubers less than 1 7/8 inches in diameter, small vine and late emergence
MSZ413-6P	Colonial Purple x MSU200-5PP	0.2	An even split of A and B sized tubers, moderate silver scurf

* 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. 2018 Michigan Statewide Russet Potato Variety Trials
Overall Averages- Twelve Locations

	CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[4] (%)							
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[5]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
Castle Russet[ij]	519	608	85	8	85	0	7	1.072	75	5	0	0	0.0	1.8	4.2	mod alligator hide, misshapen POs
A08433-4VRRUS[cfghijkl]	499	614	82	7	75	7	11	1.075	7	10	1	0	0.2	3.0	4.3	sl alligator hide, misshapen and points in POs
Reveille Russet[bcdefghijkl]	460	546	84	7	80	4	9	1.067	2	3	3	0	0.3	2.3	3.1	tr alligator hide, longer blocky tuber shape
Caribou Russet[bcdefghijkl]	459	558	83	5	78	5	12	1.073	3	10	22	1	0.2	3.4	3.5	sl alligator hide, GC in POs, tr alligator hide
A07061-6RUS[bcdefghijkl]	440	544	81	13	79	2	6	1.073	0	6	1	0	0.9	3.1	3.8	sl alligator hide, knobs and misshapen in POs
Mountain Gem[bcefhil]	440	530	83	7	77	6	10	1.076	24	3	0	1	0.0	2.8	4.1	mod alligator hide, deep apical eyes
W10612-8RUS[cfj]	431	552	86	7	86	0	7	1.072	23	4	17	0	1.0	2.8	2.9	mod alligator hide, misshapen POs
CO10091-1RUS[ij]	430	511	84	10	84	0	6	1.074	14	2	4	0	0.6	1.8	3.1	mod alligator hide, GC and misshapen in POs
A071012-4BFRUS[cfgjk]	410	524	76	8	76	0	16	1.085	21	1	1	1	0.5	3.1	4.0	medium to heavy russeting, skin flaking
Russet Norkotah[abcdefghijkl]	**409**	**516**	**77**	**11**	**74**	**3**	**12**	**1.071**	**18**	**18**	**1**	**0**	**0.1**	**3.1**	**2.9**	**mod alligator hide, GC and misshapen in POs**
CW08071-2RUS[abcdefghijkl]	407	478	84	11	81	3	5	1.074	6	9	4	0	0.5	3.1	3.0	mod alligator hide, blocky shape, oval tuber type
Silverton Russet[abcdefghijkl]	**391**	**472**	83	**10**	**80**	**3**	**7**	**1.067**	**8**	**7**	**11**	**1**	**0.3**	**3.3**	**3.7**	**attractive uniform tuber type and appearance**
WAF10612-1RUS[cijk]	389	518	72	14	72	0	14	1.073	9	7	1	0	2.3	2.9	3.5	mod alligator hide, misshapen and knobs in POs
Vanguard[abcdefghijkl]	387	467	83	8	81	2	9	1.064	0	6	0	0	0.1	2.9	2.4	medium russet skin type, uniform tuber profile
AF5179-4RUS[cfgijk]	368	531	71	8	70	1	21	1.080	3	2	12	0	1.1	2.4	3.5	non uniform tuber type, poor tuber shape
A06021-1TRUS[cfghijkl]	366	464	78	10	75	3	12	1.078	11	8	3	0	0.5	2.4	3.0	mod alligator hide, misshapen and GC in POs
AF5091-8RUS[abcdefghijkl]	365	451	81	9	77	4	10	1.064	2	9	6	0	0.5	2.9	2.9	heavy eyebrows, mod skinning, mod alligator hide
AF5406-7RUS[bcfghjkl]	351	497	71	9	62	9	20	1.074	8	4	3	0	0.2	2.9	3.6	sl alligator hide, lighter russet skin type
W10594-16RUS[cfghjkl]	351	438	76	16	72	4	8	1.076	5	2	2	0	0.5	3.1	3.1	light russet skin type, mod skinning
CO05068-1RUS[abcdefghijkl]	348	498	70	18	68	2	12	1.087	23	12	11	1	0.2	3.2	3.8	mod skinning, lighter russet skin, sl alligator hide
CO10087-4RUS[ij]	293	411	71	15	71	0	14	1.075	49	3	3	0	0.3	2.2	2.6	heavy russet skin type, GC in POs
AF5312-1RUS[bcdefghijlk]	285	418	68	18	67	1	14	1.070	8	1	2	0	0.3	3.0	2.5	heavy russet skin type, misshapen and GC in POs
Goldrush Russet[cefi]	**271**	**428**	**63**	**16**	**62**	**1**	**21**	**1.065**	**5**	**10**	**0**	**0**	**0.0**	**2.6**	**2.6**	**misshapen and GC in POs, heavy rysset skin**
CO09036-2RUS[abcdefghijkl]	234	418	56	30	55	1	14	1.073	18	4	0	0	0.2	2.9	3.7	bottlenecking in POs, smaller tuber size profile
CO07049-1RUS[bcdefghijkl]	198	381	51	41	50	1	8	1.073	2	4	1	0	0.1	2.7	2.9	smaller size profile, medium russet skin, sl alligator hide
CO07015-4RUS[abcdefghijkl]	194	332	55	39	54	1	6	1.072	1	8	4	0	0.0	3.0	2.2	heavy russet skin, sl skinning, mod alligator hide
MEAN	**373**	**489**	**75**	**14**	**73**	**2**	**11**	**1.073**	**13**	**6**	**4**	**0**	**0.4**	**2.8**	**3.3**	

2018 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
[g]Lennard Ag. Company, St. Joseph County
[h]Verbrigghe Potato Farm, 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 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 within trials

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

[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 (vigorous vine, some flowering)

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

Table 10. 2018 Michigan Statewide Tablestock Potato Variety Trials
Overall Averages- Nine Locations

		CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[4] (%)							YELLOW FLESH		RED SKIN				
	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[5]	VINE VIGOR[7]	VINE MATURITY[8]	WAXINESS[7]	FLESH COLOR[8]	WAXINESS[7]	SKIN COLOR[9]	UNIFORMITY[10]	SILVER SCURF[11]	COMMENTS
YELLOW SKIN TYPE	Actrice[eh]	716	782	92	3	91	1	5	1.057	0	20	0	0	0.3	3.0	2.5	2.3	3.3					misshapen POs
	Jelly[c]	462	602	77	13	77	0	10	1.064	0	70	0	0	0.5	3.5	4.5	2.0	3.5					pear shaped tubers in POs
	MSX156-1Y[abcegh]	444	480	79	18	77	2	3	1.063	2	1	9	0	1.1	2.7	3.6	2.1	2.4					round tuber type, netted skin, sl alligator hide
	NY149[abcdeghi]	388	477	73	24	73	0	3	1.072	0	22	0	1	0.5	3.6	3.5	2.1	2.7					pink eyes, tr alligator hide, sl skinning
	Laperla[abcdefghi]	374	477	73	21	69	4	6	1.052	3	3	3	0	1.7	3.7	2.0	3.1	2.1					non uniform tuber type, pear shaped pickouts
	W9576-11Y[abcdeghi]	363	456	75	19	75	0	6	1.058	0	7	0	0	0.3	3.2	2.4	2.9	3.1					larger tubers, mod alligator hide, netted skin
	Orlena[abcdefghi]	353	458	71	11	69	2	18	1.058	0	7	0	4	1.0	2.6	2.6	3.1	3.5					GC and pear shapes in POs
	AC10376-1W/Y[eh]	343	542	63	31	63	0	6	1.066	0	23	0	0	1.6	3.0	2.5	2.3	3.3					misshapen POs
	MSV093-1Y[c]	335	445	74	13	73	1	13	1.061	0	20	0	0	0.5	2.0	5.0	2.0	3.0					mod alligator hide
	Wendy[abcdeghi]	334	494	60	36	60	0	4	1.061	0	6	0	0	1.3	2.9	3.5	3.0	3.2					pointed tubers in POs, oval to oblong tubers
	Alegria[abcdeghi]	333	433	73	18	73	0	9	1.072	0	8	1	0	0.6	3.3	3.3	2.1	2.8					GC in POs, sl alligator hide, tr powdery scab, netted ski
	Soraya[abcdeghi]	330	458	64	21	64	0	15	1.059	0	8	2	0	0.2	3.1	3.1	2.5	3.6					mod alligator hide, misshapen POs
	Yukon Gold[abcdefghi]	**321**	**376**	**84**	**9**	**80**	**4**	**7**	**1.078**	**10**	**10**	**0**	**2**	**1.3**	**3.0**	**2.8**	**2.6**	**3.0**					**misshapen POs, sl alligator hide**
	Lady Terra[egh]	315	463	64	31	64	0	5	1.078	0	10	3	0	1.2	3.5	4.0	1.8	2.1					sl alligator hide and powdery scab, oval tuber shape
	MSZ407-2Y[cegh]	309	377	77	8	76	1	15	1.075	0	2	0	0	0.3	2.7	2.7	1.8	2.0					mod alligator hide, non uniform tuber type, skinning
	CO10097-2W/Y[gh]	304	415	73	24	73	0	3	1.067	0	20	0	5	2.9	2.8	3.3	1.3	3.0					mod alligator hide
	Bonnata[abcdefghi]	283	418	58	31	58	0	11	1.070	1	21	1	0	1.5	3.3	2.9	3.1	1.9					bottlenecking in POs, oblong, bright skin
	MST252-1Y[abcdefghi]	281	370	70	22	68	2	8	1.070	0	8	0	1	0.7	2.4	2.8	2.4	1.8					mod alligator hide, GC in POs, sl powdery scab
	Queen Anne[abcdefghi]	278	430	58	39	58	0	3	1.059	0	12	0	0	0.4	2.8	2.7	3.5	3.4					uniform oval tuber type, smooth skin
	Lady Anna[egh]	226	404	50	41	50	0	9	1.077	3	17	0	0	1.2	2.8	4.1	2.7	2.4					bright appearance, sl alligator hide, long tuber type
	Lady Claire[egh]	224	390	55	39	55	0	6	1.080	0	1	0	0	1.0	2.8	2.7	1.4	3.0					tr powdery scab, skin flaking, pointed POs
	Rock[gh]	154	350	42	55	42	0	3	1.074	0	3	25	0	2.0	3.0	4.8	2.8	2.0					non uniform tuber type
	CO10064-1W/Y[gh]	153	290	44	47	44	0	9	1.084	0	10	15	0	1.4	3.3	4.1	1.5	3.3					netted skin
	CO10098-4W/Y[gh]	130	306	36	60	36	0	4	1.086	0	7	5	0	2.5	3.7	3.7	2.3	3.5					small uniform tuber type
	Jazzy[abcdefghi]	57	255	17	68	17	0	15	1.063	0	20	0	0	0.7	3.1	2.5	3.3	2.6					long tubers, tr alligator hide, pear shaped POs
	CO10098-5W/Y[gh]	50	223	21	67	21	0	12	1.087	0	3	0	0	2.5	3.3	2.8	1.4	4.5					mod alligator hide, rough skin
	MEAN	302	430	62	30	62	1	8	1.069	1	13	3	1	1.1	3.0	3.2	2.4	2.9					
RED SKIN TYPE	Cerata[abcdefghi]	439	512	79	17	75	4	4	1.063	0	5	1	0	0.9	3.3	4.1			2.7	2.7	3.6	1.9	mod silver scurf, skin flaking
	AF4831-2R[abcdefghi]	416	541	72	25	72	0	3	1.061	0	10	3	0	1.5	2.9	3.1			3.3	3.0	3.3	2.1	mod silver scurf, oval to oblong tuber type
	Red Marker #2[abcdefghi]	381	454	79	18	79	0	3	1.075	0	7	0	0	0.9	3.5	3.5			2.4	2.5	3.1	2.0	light skin color, mod skinning
	AF5806-1[g]	357	455	79	14	79	0	7	1.063	0	0	0	0	0.0	4.0	4.0			3.0	1.0	3.0	0.0	light pink skin, mod skinning
	QSNDSU07-4R[gh]	338	430	78	11	78	0	11	1.061	0	13	45	0	2.0	3.3	2.5			2.3	2.6	3.0	1.4	smooth light red skin
	W8405-1R[abcdefghi]	334	425	73	23	72	1	4	1.060	0	10	9	0	0.4	3.4	3.2			3.0	2.7	3.2	1.9	sl silver scurf, oval to oblong tuber type
	W8890-1R[abcdefghi]	313	396	72	25	72	0	3	1.063	2	25	1	1	1.3	3.5	2.5			2.8	3.7	3.9	2.0	mod silver scurf, attractive appearance
	CO98012-5R[abcdefghi]	311	415	66	31	65	1	3	1.070	0	3	0	0	1.9	3.2	3.5			3.3	3.6	3.7	2.1	attractive tuber type and size profile
	Dark Red Norland[acdefghi]	**289**	**346**	**81**	**15**	**80**	**1**	**4**	**1.059**	**1**	**8**	**2**	**0**	**0.4**	**3.5**	**1.8**			**2.5**	**2.9**	**2.9**	**1.9**	**mod powdery scab and silver scurf**
	NDAF1134884B-1[g]	272	402	68	13	68	0	19	1.058	0	10	0	0	0.0	3.0	2.0			2.5	3.0	4.0	0.0	light skin netting
	NDTX4784-7R[g]	254	313	81	15	81	0	4	1.061	0	10	0	0	0.0	2.0	1.5			3.0	3.5	4.0	0.0	mod skinning
	AF5831-2[g]	248	334	74	19	74	0	7	1.078	0	0	0	0	0.5	3.5	3.0			2.5	2.5	3.0	0.0	sl skinning
	CO06215-2R[g]	236	374	63	33	63	0	4	1.074	0	10	0	0	0.0	3.0	4.5			2.0	3.5	4.0	1.0	attractive round tuber type, mod skinning
	W8893-1R[gh]	225	327	65	30	65	0	5	1.058	0	7	0	0	0.4	3.6	1.8			3.3	3.4	2.7	1.7	sl alligator hide
	NDAF102696C-5[g]	224	344	65	33	65	0	2	1.067	0	0	0	0	0.0	3.0	1.5			2.5	3.0	3.0	0.0	attractive round tuber type, severe skinning
	CO99076-6[Rg]	214	298	72	15	72	0	13	1.068	0	0	0	0	0.0	3.0	4.0			3.0	3.5	3.5	0.0	
	NDAF12129-6[g]	198	354	56	32	56	0	12	1.070	0	20	0	0	0.0	3.0	3.0			3.0	3.5	4.0	0.0	sl skinning
	NDAF12143-1[g]	195	295	66	25	66	0	9	1.063	0	20	0	0	0.0	3.0	3.0			2.0	3.5	3.0	1.5	
	CO04159-1R[g]	186	280	66	30	66	0	4	1.063	0	0	0	0	1.5	2.5	2.0			3.0	3.0	3.5	0.5	round tuber type
	NDAF12198B-5[g]	162	292	55	38	55	0	7	1.052	0	0	0	0	1.5	3.0	2.0			2.0	3.0	2.0	0.5	
	COTX02293-4R[g]	158	286	55	38	55	0	7	1.061	0	20	0	0	0.0	3.0	2.5			3.0	4.0	4.0	0.0	
	CO99256-2R[g]	133	229	58	19	58	0	23	1.066	0	40	0	0	0.0	3.0	4.5			3.0	4.0	4.0	0.0	sl skinning, attractive skin color
	NDTX071258BS-1R[g]	108	281	39	35	39	0	26	1.067	0	20	0	0	1.5	3.3	1.5			2.5	3.7	3.5	0.3	attractive round shape and skin finish
	COTX00104-6R[g]	82	119	78	14	69	9	8	1.063	0	20	0	0	0.0	1.5	3.0			1.0	4.0	4.0	0.0	
	MSX569-1R[g]	62	119	52	42	52	0	6	1.061	0	0	0	0	0.0	2.0	3.0			3.0	4.0	3.0	0.0	red color in vascular ring
	MEAN	245	345	68	24	67	1	8	1.064	0	10	2	0	0.6	3.0	2.8			2.7	3.2	3.4	0.8	

ROUND WHITE TYPE	White Beauty[e]	562	608	92	7	92	0	1	1.071	0	0	10	0	0.0	3.5	5.0							sl powdery scab
	Harmony[e]	551	648	85	9	85	0	6	1.067	0	20	0	0	0.0	2.5	3.5							misshapen POs
	Reba[abcdei]	**462**	**507**	**87**	**10**	**85**	**2**	**3**	**1.069**	**8**	**3**	**0**	**2**	**0.3**	**2.9**	**2.8**							**flattened tuber shape, sl powdery scab**
	Libertie[e]	407	625	65	14	65	0	21	1.055	10	0	0	20	0.0	3.0	4.0							mod powdery scab, non uniform tuber type
	Moonlight[e]	387	454	85	13	85	0	2	1.072	0	10	0	0	0.0	4.5	4.5							severe alligator hide, surface cracking
	MSY111-1[abcdei]	384	446	78	17	76	2	5	1.064	0	10	0	0	0.8	3.1	3.2							tr powdery scab, round tuber shape, netted skin
	MSX497-6[bci]	375	409	92	3	91	1	5	1.067	0	10	3	0	1.7	2.7	3.0							larger tuber type, sl alligator hide
	AF4138-8[abcdei]	345	410	77	22	77	0	1	1.065	0	23	0	0	1.1	2.9	2.8							uniform round tuber type
	AF5280-5[abcdei]	336	398	81	16	81	0	3	1.062	0	18	0	0	0.3	3.3	1.6							oval to oblong tuber type, light skin netting
	Rock[e]	308	507	61	39	61	0	0	1.075	0	0	10	0	0.5	3.0	3.0							oval tuber type, poor skin finish
	Nadine[ei]	305	388	77	22	77	0	1	1.057	0	0	0	0	0.5	3.3	2.8							bright skin color and appearance
	Superior[de]	**300**	**385**	**78**	**17**	**78**	**0**	**5**	**1.071**	**10**	**5**	**0**	**0**	**0.0**	**3.3**	**1.3**							**flat oval tuber type, non uniform**
	Onaway[ci]	**287**	**386**	**74**	**14**	**73**	**1**	**12**	**1.068**	**0**	**15**	**5**	**0**	**1.3**	**3.5**	**2.3**							**deep stem ends, blocky tuber type**
	MEAN	385	475	79	16	79	0	5	1.066	2	9	2	2	0.5	3.2	3.0							
NOVELTY TYPE	MSV443-1PP[ae]	293	375	50	46	50	0	4	1.054	0	0	0	0	0.3	2.3	3.5			3.5	3.5	4.0	3.8	mod silver scurf, misshapen POs
	MSW148-1P[abcdefi]	291	385	69	27	69	0	4	1.077	0	0	0	0	1.5	3.3	3.5			2.8	3.1	3.5	2.5	small tuber size profile, mod silver scurf
	AF5245-1P[abcdefghi]	246	330	68	28	66	2	4	1.072	10	11	1	3	0.5	3.4	2.1			3.0	4.0	3.7	2.4	mod silver scurf
	MSX324-1P[abcdfghi]	238	330	65	29	63	2	6	1.075	0	4	1	0	0.9	2.9	2.1			2.8	3.3	3.1	2.3	variable skin color and tuber shape
	MSZ413-6P[abg]	153	271	47	50	47	0	3	1.062	0	7	0	0	0.2	2.8	3.3			2.8	4.3	3.7	2.0	sl silver scurf
	MSV235-2PY[ai]	106	222	33	65	33	0	2	1.076	0	0	0	0	0.0	3.0	1.0		1.0	3.3	4.8	4.3	4.0	cream colored flesh
	MSW316-3PY[a]	8	69	12	74	12	0	14	1.043	0	0	0	0	0.0	1.5	-		2.0	3.0	5.0	4.0	4.5	deep purple skin color
	MSZ107-6PP[a]	1	27	4	90	4	0	6	1.063	0	0	0	0	0.5	1.5	-			4.5	5.0	4.5	5.0	
	MSZ109-5RR[a]	0	110	0	100	0	0	0	1.042	0	0	0	0	0.5	1.0	-			3.0	4.0	4.5	3.5	very small tubers
	MEAN	149	236	39	57	38	0	5	1.063	1	2	0	0	0.5	2.4	2.6		1.5	3.2	4.1	3.9	3.3	
	TRIAL MEAN	**279**	**385**	**64**	**29**	**64**	**1**	**7**	**1.066**	**1**	**10**	**2**	**1**	**0.7**	**3.0**	**3.0**	**2.4**	**2.8**	**2.8**	**3.4**	**3.5**	**1.5**	

2018 TABLESTOCK VARIETY TRIAL SITES	[1]SIZE	[2]SPECIFIC GRAVITY	[3]RAW	[4]COMMON SCAB RATING	[5]VINE VIGOR RATING	[6]VINE MATURITY RATING
[a]4-L Farms, Allegan County	**Non-russet tablestock**	Data not replicated	**(percent of tubers out of 10)**	0.0: Complete absence of surface or pitted lesions	Date: Variable	Date: Variable
[b]Crawford Farms, Montcalm County	Bs: < 1 7/8"		HH: Hollow Heart	1.0: Presence of surface lesions	Rating 1-5	Rating 1-5
[c]Horkey Brothers, Monroe County	As: 1 7/8" - 3 1/4"		VD: Vascular Discoloration	2.0: Pitted lesions on tubers, though coverage is low	1: Slow emergence	1: Early (vines completely dead)
[d]Jenkins Farms, Kalkaska County	OV: > 3 1/4"		IBS: Internal Brown Spot	3.0: Pitted lesions common on tubers	5: Early emergence	5: Late (vigorous vines, some flowering)
[e]Kitchen Farms, Antrim County	PO: Pickouts		BC: Brown Center	4.0: Pitted lesions severe on tubers		
[f]Verbrigghe Potato Farms, Delta County				5.0: More than 50% of tuber surface area covered in pitted lesions		
[g]Walther Farms, Tuscola County						
[h]Walther Farms, St. Joseph County	[7]WAXINESS RATING	[8]FLESH COLOR	[9]SKIN COLOR	[10]UNIFORMITY OF SKIN COLOR	[11]SILVER SCURF	
[i]Wilk Farms, Presque Isle County	1: Heavy netting, buff	1: White	1: Light pink	1: Highly variable, non-uniform	0: No incidence of silver scurf	
	5: Waxy, smooth	5: Dark yellow	5: Dark red	5: Highly uniform, color throughout	5: High incidence of silver scurf	

Volunteer Potato Control

Potatoes that are left in the field after harvest are considered volunteer potatoes. Historically harsh winter temperatures kill tubers that remain in the field after harvest. Although, in regions where winters are mild and soil temperatures are not cold enough to kill tubers left in the field, tubers can survive overwinter and become a serious weed problem the following spring. Not only do volunteer potatoes compete with crops and reduce yield, but they also harbor insects, diseases, and nematodes that can infest neighboring or future potato crops. Volunteer potatoes may become more problematic in the future given current climate predictions. Further complicating this problem is the fact that volunteer potatoes are difficult to control. Currently, there are no herbicides available that will completely control volunteer potatoes and significantly reduce the number of daughter tubers produced per plant. Research conducted evaluating volunteer potato control in Michigan was last conducted in 2002. Since 2002, new HPPD (4-Hydroxyphenylpyruvate dioxygenase, pigment inhibitors) inhibiting herbicides have been approved for use in corn and may provide additional options for volunteer potato control. Furthermore, combinations of HPPD and PSII (photosystem II) inhibitors exhibit synergistic activity. Therefore, the objective of this demonstration was to evaluate volunteer potato control with HPPD inhibiting herbicides alone and in combination with the PSII inhibitor atrazine to explore potential beneficial herbicide interactions.

With the help of Chris Long (MSU Potato Extension Specialist), volunteer potatoes were "planted" on June 13th by scattering seed pieces by hand and working into the ground with a cultipacker. Herbicide treatments (Table 1) were applied on July 11th. Volunteer potatoes that were 6, 12, and 20 inches tall at the time of application were flagged, dug on August 15th, and photographed. Overall, the addition of atrazine to HPPD inhibiting herbicides improved volunteer potato control and in many treatments prevented daughter tuber formation. In general, as the size of volunteer potatoes increased control decreased. The Michigan Potato Industry Commission supported this research.

Table 1. Postemergence herbicide treatment list applied July 11th.

Herbicide Trade name	Rate (Formulation/A)	Additives
Callisto	3 fl oz	1% COC + 8.5 lb/100 gal AMS
Callisto + Aatrex (atrazine) 90 WG	3 fl oz + 0.5 lb a.i.	1% COC + 8.5 lb/100 gal AMS
Armezon/Impact	0.75 fl oz	1% MSO + 17 lb/100 gal AMS
Armezon/Impact + Aatrex 90 WG	0.75 fl oz + 0.5 lb a.i.	1% MSO + 17 lb/100 gal AMS
Laudis	3 fl oz	1% MSO + 8.5 lb/100 gal AMS
Laudis + Aatrex 90 WG	3 fl oz + 0.5 lb a.i.	1% MSO + 8.5 lb/100 gal AMS
Acuron Flexi	2 qt	0.25% NIS
Acuron Flexi + Aatrex 90 WG	2 qt + 0.5 lb a.i.	0.25% NIS
Shieldex	1.35 fl oz	1% MSO + 8.5 lb/100 gal AMS
Shieldex + Aatrex 90 WG	1.35 fl oz + 0.5 lb a.i.	1% MSO + 8.5 lb/100 gal AMS

COC = crop oil concentrate, AMS = ammonium sulfate, MSO = methylated seed oil, NIS = nonionic surfactant

Questions?

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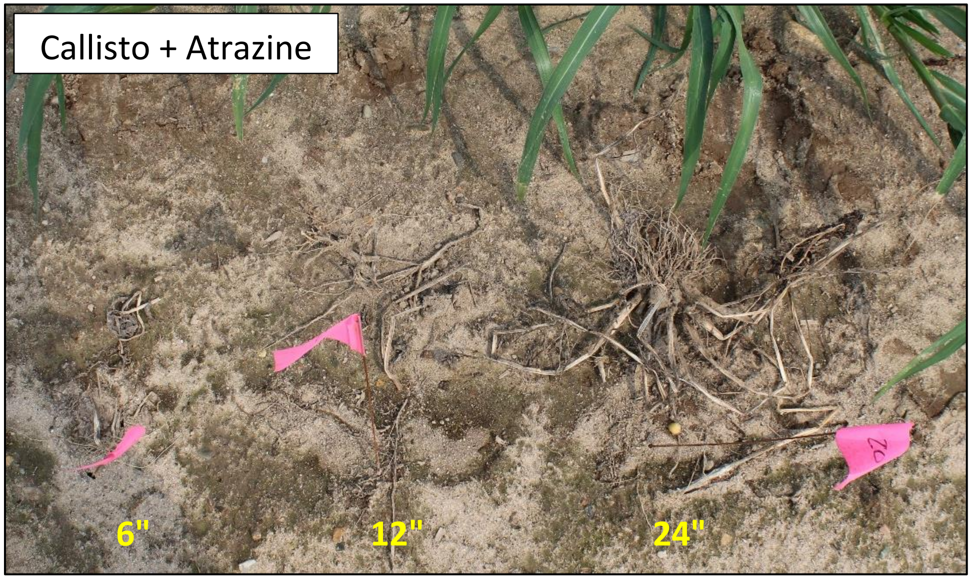
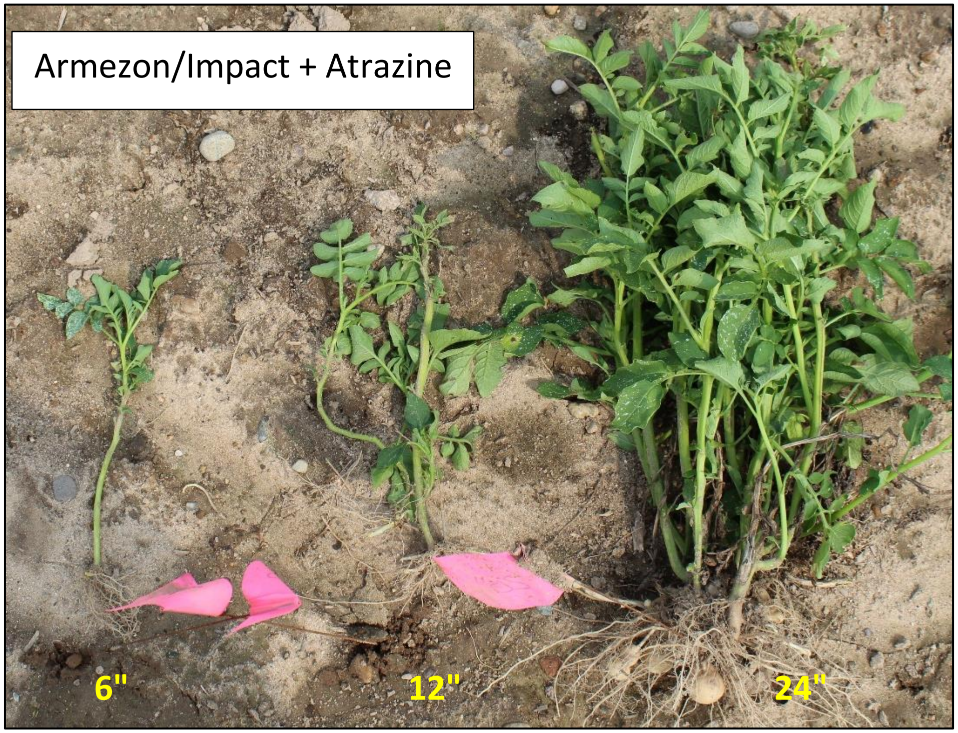
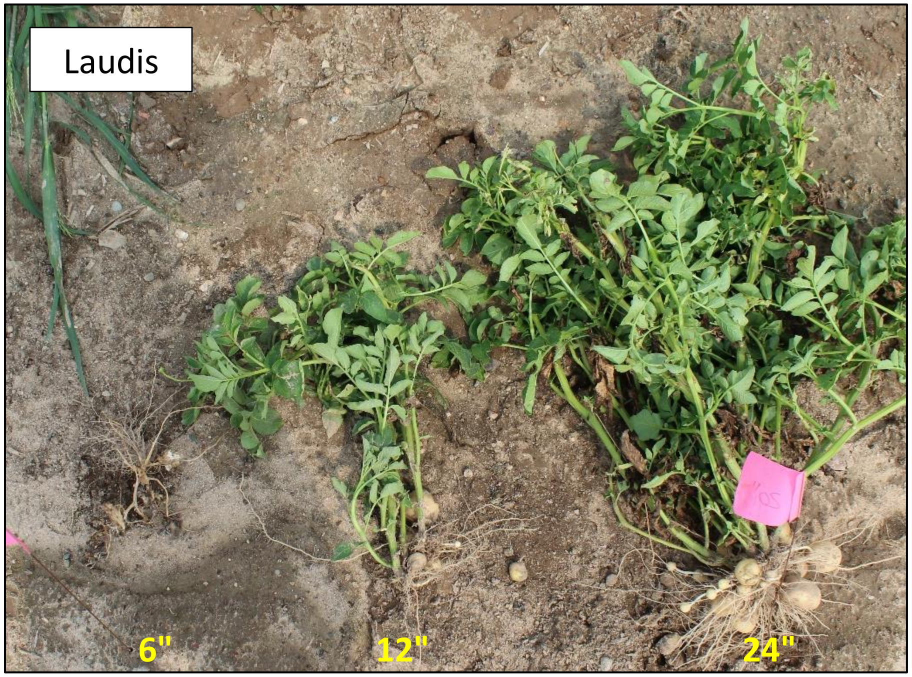
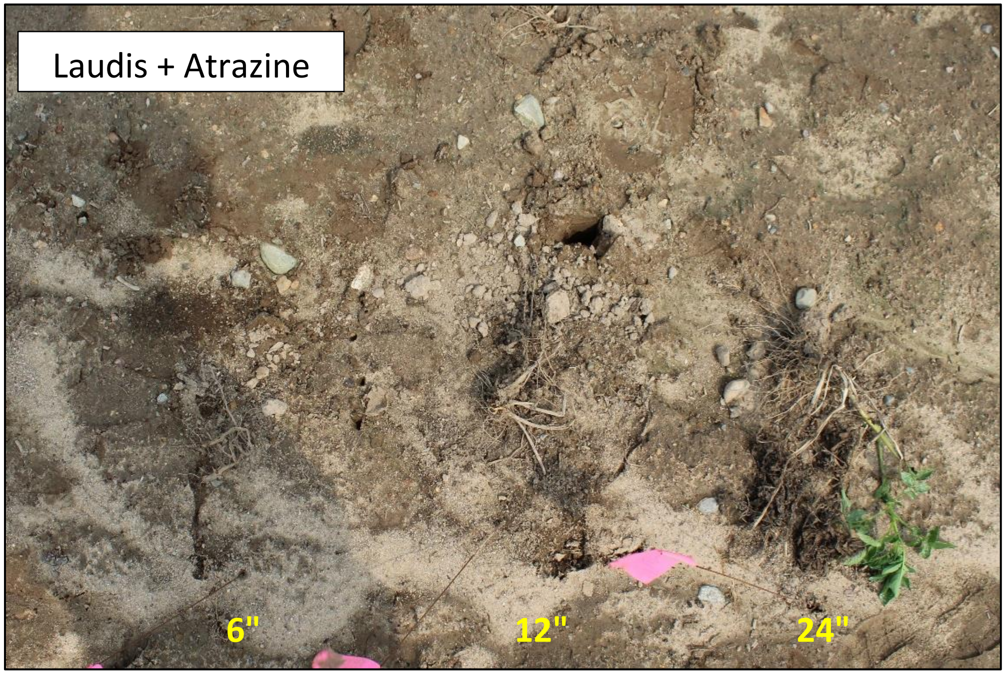
Callisto
6"
12"
24"


Callisto + Atrazine
6"
12"
24"

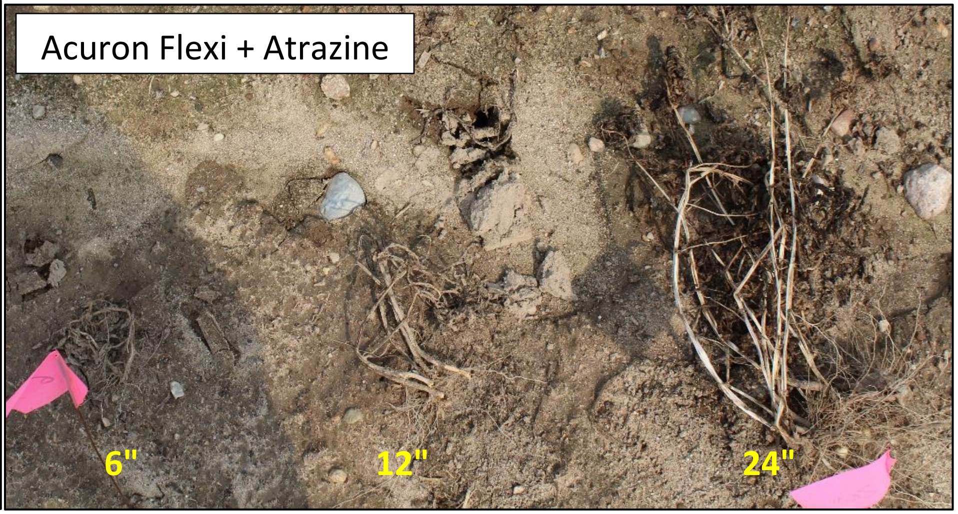

Armezon/Impact
6"
12"
24"


Armezon/Impact + Atrazine
6"
12"
24"

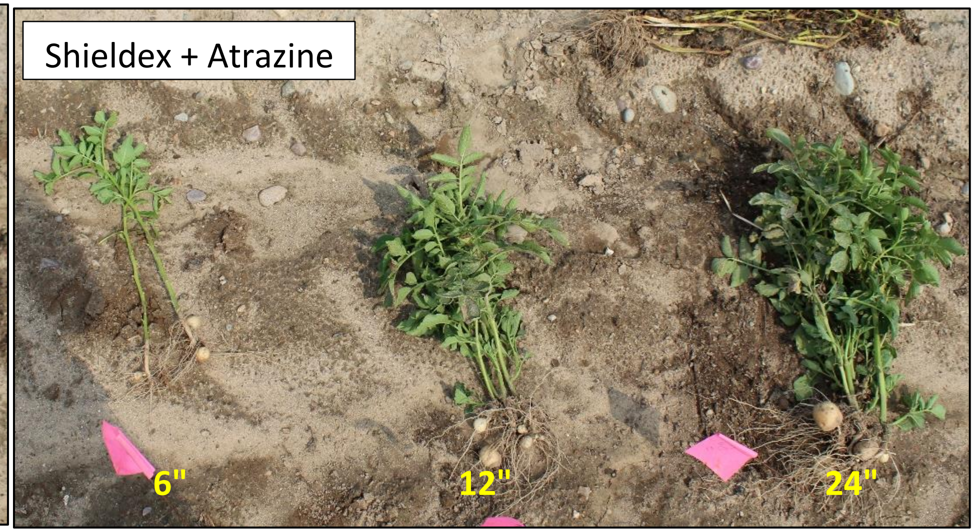

Laudis
6"
12"
24"


Laudis + Atrazine
6"
12"
24"


Acuron Flexi
6"
12"
24"


Acuron Flexi + Atrazine
6"
12"
24"


Shieldex
6"
12"
24"


Shieldex + Atrazine
6"
12"
24"

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

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

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

In the spring of 2015,2016, and 2018, 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 CFPM 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.

In 2018 six of the same cover crop species that were planted in 2016 were grown again in 2018. Pearl Millet 'Millex 32' was not grown. The same experimental design from previous years was used for this trial at the MRC. As in 2016, corn produced the highest above ground and total biomass as the ears were included in the weight calculations. However, the sorghum sudangrass had the highest biomass at the first cutting and pearl millets 'Wonderleaf' and 'CFPM 101' had the highest biomass at the second cutting. In 2018, biomass was measures on July 19th, August 14th, and finally on October 19th. The two initial cuttings excluded the corn control treatment. Pearl millet 'CFPM 101' was also the tallest cover crop at the first and second cutting. The 2018 total biomass accumulation results are listed in Table 5.

2018 was the last year of cover crop trials in Phase 1 of this project. Summary data is presented in Table 6. Twelve different cover crop varieites were evaluated in 2015, 2016, and 2018. While dates were variable between years, there were significant differences in cover crop above ground biomass at each of the three cutting dates. Common oat 'Ida' produced the most biomass at the first cutting while pearl millet 'Millex 32' produced the most biomass at the second cutting. Corn had the highest biomass at the third cutting as it was excluded from the first two cuttings and grain weight was included in the biomass. Therefore, corn had the highest total biomass over all three ears, followed by Teff and pearl millet 'Wonderleaf.' When below ground biomass was included in the total biomass calculation, pearl millet 'Millex 32' had the highest total root and shoot biomass after corn. When considering only below ground biomass, common oat 'Ida' had the second highest root biomass after corn.

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

Cover Crop Treatment	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] Bs	As	OV	PO	SP GR	RAW TUBER QUALITY[2] (%) HH	VD	IBS	BC	COMMON SCAB RATING[3]	ROOT LESION NEMATODE (#/100 g soil)	ROOT LESION NEMATODE (#/1 g root tissue)	VERTICILLIUM DAHLIAE (# 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	As	OV	PO	SP GR	RAW TUBER QUALITY[2] (%) HH	VD	IBS	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
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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)

Table 5: 2018 Grass Cover Crop Total Biomass (lb/A) and Height (In)

Species	Common Name	Variety	Total Biomass (lb/A)	Maximum Height (In)
Avena Sativa	Corn	-	9874^{a}	72^{a}
Pennisetum glaucum	Pearl Millet	Tifleaf 3	4680^{b}	51^{ab}
Pennisetum glaucum	Pearl Millet	Wonder Leaf	4765^{b}	44^{bc}
Pennisetum glaucum	Pearl Millet	CFPM 101	6246^{ab}	60^{ab}
Eragrosis tef	Teff	White	2400^{b}	21^{c}
Sorghum bicolor x S. bicolor var sudanese	Sorghum Sudan Grass	Sweet Bites	4268^{b}	44^{bc}

*Treatment means followed by the same letter are not considered significantly different based on Tukey's HSD test (α=0.05)

Corn aboveground biomass includes grain weight

Maximum height was measured on 10/19/18

Table 6: Cover Crop Above and Below Ground Biomass Averages from 2016, 2016, and 2018

Cover Crop Treatment Information					Dry Weight Shoot Biomass											
Species	Common Name	Variety	Code	Year(s) Grown	1st Cutting	Letter	2nd Cutting	Letter	3rd Cutting	Letter	Total Shoot Biomass	Letter	Total Root Biomass	Letter	Total Root and Shoot Biomass	Letter
Zea mays	Corn	N/A	CN	16, 18	128	F	-	-	20059	A	20059	A	5416	A	25475	A
Pennisetum glaucum	Pearl Millet	Millex 32	PM2	15, 16	1517	B	7401	A	1964	B	10882	B	913	B	11534	B
Pennisetum glaucum	Pearl Millet	CFPM 101	PM3	15,16,18	1253	BCD	5018	AB	2200	B	8472	BC	1879	B	10008	BC
Pennisetum glaucum	Pearl Millet	Wonderleaf	PM4	16, 18	926	CDE	4820	AB	2405	B	8151	BCD	1155	B	9305	BCD
Pennisetum glaucum	Pearl Millet	Tifleaf 3	PM1	15, 16, 18	946	CDE	3928	BC	1868	B	6742	BCD	1411	B	7896	BCD
Setaria italica	Sorghum Sudan Grass	N/A	SS	16, 18	773	DEF	-	-	1956	B	5558	BCD	1712	B	7271	BCD
Panicum miliaceum	Teff	White	TF	16, 18	359	F	-	-	2770	B	4774	CD	940	B	5714	BCD
Avena Sativa	Common Oat	Ida	OAT	15	3561	A	320	CD	0	B	3880	BCD	1039	AB	4227	BCD
Setaria italica	German Millet	N/A	GM1	15	1514	BC	2479	BCD	0	B	3992	BCD	-	-	3992	BCD
Setaria italica	Foxtail Millet	White Wonder	FM1	15	1397	BCD	2372	BCD	0	B	3769	BCD	-	-	3769	BCD
Panicum miliaceum	Proso Millet	White	PROM1	15	1887	B	219	D	0	B	2105	CD	-	-	2105	CD
Echinochloa esculenta	Japanese Millet	N/A	JM2	15	272	EF	442	CD	0	B	714	D	-	-	714	D
Echinochloa esculenta	Japanese Millet	N/A	JM1	15	-	F	581	CD	0	B	709	D	-	-	709	D
			ANOVA:		**<.0001**		**0.0009**		**<.0001**		**<.0001**		**0.0209**		**<.0001**	
			LSD:		855		3011		4823		5757		2540		6582	

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

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

Objective 2: 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 7) 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 8) 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 14^{th} 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).

Cover crop research at Kitchen Farms concluded in 2017. The results of both the co-seeded and interseeded plots are summarized in Tables 9 and 10, respectively. In the co-seeded trial Sorghum sudangrass produced the most belowground biomass at 1827 lb/A, while pearl millet ‘CFPM 101’ produced the least. Sorghum sudangrass and ‘CFPM101’ produced the most total biomass, although there was no statistically significant difference between the cover crop species. Alfalfa produced the highest biomass when co-seeded with pearl millet ‘Tifleaf 3’ and ‘CFPM 101.’ Finally, there was the lowest amount of weed biomass in the ‘CFPM 101,’ ‘Tifleaf 3,’ and sorghum sudangrass co-seeded plots. There was no significant difference in the number of nematodes present between cover crop treatments in these two years in both the co-seeded and interseeded plots (Table 9). In the interseeded trial pearl millet 'Tifleaf 3' produced the highest above ground biomass while Teff produced the lowest. Alfalfa produced the higest biomass when grown in conjunction with Teff, but this was likely due to the poor stand of Teff and resulted in an imbalanced grass:alfalfa biomass ratio. In all treatments, the alfalfa biomass was a factor of 10 larger than the grass biomass (Table 10).

In 2018, 'Superior' potatoes were planted over the co-seeded and interseeded plots at Kitchen Farms. Potatoes grown over the co-seeded CFPM 101 pearl millet treatment had the highest yield in the co-seeded trial, while potatoes grown over Interseeded Tifleaf 3 had the highest total yield in the Interseeded trial (Table 11). There were no statistically significant differences in yield, size breakdown, or potato internal quality in 2018. Additionally, there was no significant difference in root lesion nematode concentration between the co-seeded and Interseeded trial or between different cover crop treatments within a trial.

Table 7: 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 8: 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 9: 2016 and 2017 Crop Biomass at Kitchen Farms

		Co-Seeded Season Total Dry Biomass								
		Grass			Alfalfa			Weeds		
		Above	Below	Total	Above	Below	Total	Above	Below	Total
Common Name	Variety	lb/A								
Alfalfa only		-	-	-	3521^{a}	1335^{a}	4856^{a}	$4,045^{a}$	582^{a}	4627^{a}
Pearl millet	CFPM 101	6812	429^{c}	7241	1625^{b}	647^{b}	2272^{b}	389^{c}	217^{b}	606^{c}
Pearl millet	Millex 32	6517	552^{c}	7069	1642^{b}	469^{b}	1919^{b}	613^{bc}	200^{b}	814^{bc}
Pearl millet	Tifleaf 3	5594	559^{c}	6152	1651^{b}	727^{ab}	2378^{b}	516^{c}	107^{b}	623^{c}
Sorghum sudangrass	Super sugar	6656	1827^{a}	8542	1082^{b}	534^{b}	1616^{b}	484^{c}	88^{b}	572^{c}
Teff	Dessie	4095	642^{c}	4736	222^{b}	141^{b}	363^{b}	$1,147^{bc}$	180^{b}	1327^{bc}
Cereal rye	Guardian	1907	973^{bc}	2880	803^{b}	392^{b}	1195^{b}	$1,979^{b}$	214^{b}	2193^{b}
Annual ryegrass	Centurion	3058	1513^{ab}	4571	657^{b}	337^{b}	995^{b}	$1,037^{bc}$	212^{b}	1249^{bc}
	MEAN	5474	875	6331	1594	641	2208	1276	225	1501
	ANOVA	0.086	**0.001**	0.163	**0.029**	**0.045**	**0.029**	**0.000**	**0.015**	<0.0001
	LSD		655		1619	608	2192	1381	248	1454

Treatments followed by different superscript letters have a statistically significant different using Student's T-Test (a=.05)

Table 10: 2016 and 2017 Crop Biomass at Kitchen Farms

		Interseeded Season Total Dry Biomass					
		Grass			Alfalfa		
		Above	Below	Total	Above	Below	Total
Common Name	Variety	lb/A					
Alfalfa only		-	-	-	3225	1468	4692
Pearl millet	CFPM 101	$313b^{c}$	170	484^{b}	3178	1480	4658
Pearl millet	Millex 32	355^{bc}	131	485^{b}	2950	1415	4365
Pearl millet	Tifleaf 3	669^{a}	155	824^{a}	3173	1498	4671
Sorghum-sudangrass	Super sugar	380^{b}	164	545^{ab}	2909	1476	4385
Teff	Dessie	8^{d}	8	16^{b}	3552	1995	5547
Cereal rye	Guardian	183^{bcd}	65	248^{b}	3257	1892	5148
Annual ryegrass	Centurion	79^{cd}	47	126^{b}	2752	1656	4408
	MEAN	284	106	390	3125	1610	4734
	ANOVA	**0.001**	0.183	**0.013**	0.852	0.266	0.625
	LSD	241		347			

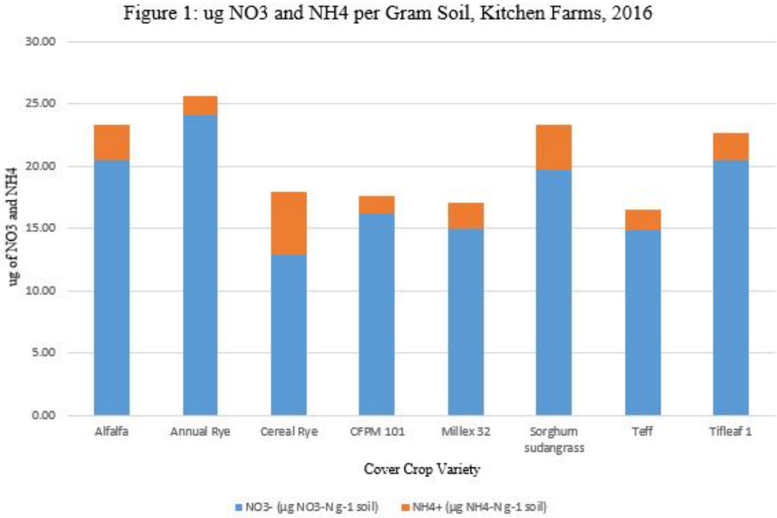
Treatments followed by different superscript letters have a statistically significant different using Student's T-Test (a=.05)

Table 12: Potato yield at Kitchen Farms in 2018

2018 Kitchens Farms Potato Yield Trial

	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR[2]	RAW TUBER QUALITY[3] (%) HH	VD	IBS	BC	COMMON SCAB RATING[4]
Co-seeded	Pearl Millet (CFPM 101)	296	457	65	16	65	0	19	1.071	0	10	0	0	0
	Cereal Rye	294	457	64	9	64	0	27	1.071	0	10	3	5	0
	Alfalfa	289	456	63	8	63	0	29	1.071	0	13	3	0	0
	Sorghum Sudangrass	289	449	64	16	64	0	20	1.071	0	5	8	5	0
	Pearl Millet (Tifleaf 3)	281	412	69	13	69	0	18	1.071	0	8	0	0	0
	Teff	250	461	55	12	55	0	33	1.072	0	5	0	0	0
	Annual Rye	239	437	55	11	55	0	34	1.069	0	8	10	0	0
	Pearl Millet (Millex 32)	239	444	54	13	54	0	33	1.070	0	5	10	0	0
		272	**447**	**61**	**12**	**61**	**0**	**27**	**1.071**	**0**	**8**	**4**	**1**	**0**
	ANOVA	0.547	0.979	0.222	0.124	0.222	-	0.056	0.363	-	0.934	0.205	0.553	-
Interseeded	Pearl Millet (Tifleaf 3)	331	455	72	12	72	0	16	1.070	8	8	5	3	0
	Pearl Millet (Millex 32)	314	447	70	14	70	0	16	1.071	0	0	0	0	0
	Pearl Millet (CFPM 101)	311	468	67	13	66	1	20	1.073	0	8	0	0	0
	Alfalfa	308	425	73	12	73	0	15	1.070	0	3	0	0	0
	Sorghum Sudangrass	298	463	65	13	65	0	22	1.069	3	10	3	0	0
		312	**452**	**69**	**13**	**69**	**0**	**18**	**1.071**	**2**	**6**	**2**	**1**	**0**
	ANOVA	0.943	0.871	0.354	0.919	0.310	0.438	0.319	0.073	0.177	0.444	0.544	0.438	-

Figure 1: ug NO3 and NH4 per Gram Soil, Kitchen Farms, 2016



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 12). No statistical analysis was conducted.

Table 12: 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

Materials and Methods:

Phase 1

The first part of this phase of the project is the pearl millet screening study. Nine grass species were planted in 2015 in a four replication, randomized block design at the MRC in early June. . 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 2016 'Superior' potatoes were planted over the cover crop plots. Root lesion nematode concentration in the soil and plant roots was evaluated, and plant stems were tested for the presence of *V. dahliae*. The potatoes were harvested, graded, evaluated for internal quality and common scab. Also in 2016, seven cover crop species were planted using the same experimental design in 2015.

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).

In 2018 six cover crop species were planted using the same experimental design as in 2017.

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 performed microbial community structure analyses and *V. dahliae* colonization on soil and potato plant tissue samples respectively collected in 2018.

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, corn produced the highest biomass due to the inclusion of grain weight, but pearl millet CFPM produced the second highest biomass. Summary data of cover crops in 2015, 2016, and 2018 indicate that after corn, Millex 32 had a statistically significant higher total root and shoot biomass than other cover crops. CFPM 101 also had a higher total biomass than 10 other cover crop treatments. While the results varied from year to year, the summary data in Table 6 show that on average, the four pearl millet species (Millex 32, CFPM 101, Wonderleaf, and Tifleaf) had a higher biomass than Teff, Oat, Sorghum sudangrass and the five millet species. Additionally, the pearl millet species all had a lower than average weed biomass at the second cutting, indicating that effective weed control is possible with these cover crops (data not shown).

This phase will conclude in 2019 with a final planting of 'Superior' potatoes over the 2018 cover crops. Data compiled and averaged from 2016 and 2017 indicates a statistically significant difference in yield, with Wonderleaf, CFPM101, and Millex 32 supporting higher potato yields than other cover crops. Potatoes grown after Wonderleaf also has the fewest Root Lesion Nematodes present in potato root tissue. Further research in 2019 is expected to continue the trend of higher potato yields after pearl millet crops.

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 7). 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 2018 potatoes were grown over both the co-seeded and Interseeded plots. No statistically significant difference was found within or between co-seeded and Interseeded trials in terms of yield, tuber internal quality, and size profile. No significant difference in root lesion nematode concentration was found in these plots in 2018.

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

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

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

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. Cousineau farms has taken over this portion of the research. Additional findings are available by contacting Monica Jean, field crops educator, at atkinmon@msu.edu.

The 2018 potato variety trial results from Upper Peninsula are now available

A small-scale field trial of 35 different potato varieties were planted in Michigan's Upper Peninsula, allowing farmers to survey results and choose promising varieties.

Photo by Monica Jean, MSU Extension

Michigan State University Extension conducts multi-location field trials every year to evaluate new potato varieties. For 2018, the Upper Peninsula trial location was at Verbrigghe TJJ Farms in Cornell, Michigan. Thirty-five different varieties of russet and tablestock varieties were planted and compared to industry standard varieties. In the field trial, every variety was sized according to the tuber type, evaluated for yield and quality, and were rated for vine vigor and maturity.

The potato trial was planted May 31, vine killed Sept. 9 and harvested Oct. 12. Harvest was delayed due to poor field conditions. Weather data received from Michigan State University's Escanaba Enviroweather station reported a growing season (plating to harvest) rainfall of 9.84 inches, much less than the five-year average rainfall of 18.3 inches. Growing degree-day (GDD) accumulation for base 40 was 2,640 (planting to vine kill).

From the 35 different varieties that were tested, the top six will be highlighted.

Seven red-skin varieties were planted with AF4831-2R yielding the highest. AF4831-2R is a uniform, dark red, waxy-skinned variety that yielded 495 cwt/a US#1 with 76 percent A and 20 percent B size tubers. It should be noted that AF4831-2R also performed well in the 2017 trial.

Seven yellow-skin varieties were planted with varieties Laperla and Orlena yielding the highest. Laperla yielded 480 cwt/a US#1 with 67 percent A and 1 percent B size tubers, and Orlena yielded 468 cwt/a US#1 with 83 percent A and 1 percent B size tubers. Both varieties exhibited yellow, waxy, smooth flesh. Although Laperla had a higher yield than Orelena, Laperla had a lower then desired specific gravity (1.056) and high percentage of oversized tubers (28 percent).

Three purple novelty type varieties were planted this season, with similar quality ratings but a range in quantity. AF5245-1P yielded 407 cwt/a US#1 with 74 percent A, 4 percent B and 22 percent oversized size tubers. MSX324-1P yielded 399 cwt/a US#1 with 82 percent A, 4 percent B and 14 percent oversized size tubers.

The top two russet varieties out of 18 planted were Mountain Gem and A07061-6RUS. Mountain Gem yielded 478 cwt/a US#1 with 49 percent A, 6 percent B and 42 percent oversized size tubers. A07061-6RUS yielded 444 cwt/a US#1 with 59 percent A, 15 percent B and 21 percent oversized size tubers. Specific gravity for Mountain Gem was 1.075 and A07061-6RUS was 1.083. Both varieties had good tuber quality ratings and A07061-6RUS had a late vine maturity rating. Bulk plantings of Mountain Gem will be done in 2019 on cooperating farms across Michigan as the next step in commercializing this variety.

Variety trials are used as a stepping-stone for farmers by informing them about variety performance in their local area. They can then use this information in their decision-making process when choosing varieties for larger scale production. By pinpointing successful varieties within a growing region, we can move towards commercial production while maintaining quality and yield. Some of the top varieties noted here will go on to a larger scale planting next growing season.

To review variety trial results for this trial and for other locations throughout Michigan, please check out our Potato Outreach Program webpage.

For further questions and inquires, email Monica Jean, field crop educator, at atkinmon@anr.msu.edu.

Potato (*Solanum tuberosum*) 'Superior'
Potato Early Die; *Verticillium dahliae,*
Pratylenchus penetrans

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Verticillium wilt management for Michigan potato production, 2018

A field trial was established 2 June (42°52'29.2"N and longitude - 85°15'09.3"W) at the Clarksville Research Center, Clarksville 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 seed pieces 18 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 25-ft-long rows spaced 34 in. apart with seed pieces 10 in. apart in the row. A 5-ft not-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). Treatment 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 11 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 30 May 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 1 Aug (60 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 60 DAP and DNA was extracted from the plant samples and subjected to quantitative PCR detection targeting *V. dahliae*. Plant stand was rated 31 (7 Jul), 39 (10 Jul) and 46 (17 Jul) DAP and relative rate of emergence was calculated as the Relative Area Under the Emergence Progress Curve [RAUEPC from 0–46 DAP, maximum value = 1.00]. Plots were not inoculated but relied on natural infestation of *Verticillium dahliae* for disease establishment. Severity of PED was measured using the Horsfall-Barratt rating scale. Severity of PED was rated 76 (17 Aug), 83 (24 Aug), 90 (31 Aug), 97 (7 Sep), 103 (13 Sep) and 111 (21 Sep) days after planting and the relative rate of disease progression was calculated as the Relative Area Under the Disease Progress Curve [RAUDPC from 0–111 DAP, maximum value = 1.00]. Plots (1 x 25-ft row) were machine-harvested on 13 Oct (134 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 14 Oct. Average daily air temperature (ºF) was 68.4, 72.7, 71.1, 64.2 and 56.2 (May, Jun, Jul, Aug, Sep and through 14 Oct respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except June with 2 days and July with 5 days. Average daily relative humidity (%) over the same period was 70.6, 66.8, 72.2, 76.9 and 80.9. Average daily soil temperature at 4 in. depth (ºF) over the same period was 69.1, 81.1, 76.9, 72.4 and 60.2. Average daily soil moisture at 4 in. depth (% of field capacity) over the same period was 0.35, 0.311, 0.328, 0.39 and 0.402. Precipitation (in.) over the same period was 2.05, 1.21, 5.44, 2.6 and 4.61”. Plots were irrigated to supplement precipitation to about 0.1 in./A/4-day period with overhead sprinkle irrigation.

Results

The 2018 growing season provided environmental extremes of excessive moisture in Aug and Oct and moisture stress at other times. However, a period of dry weather in Jul resulted in environmental conditions that were conducive to PED establishment and development. There was no significant difference in final plant stand compared to the non-treated control (Table 1). However, plots treated with Nimitz 7 pt/a (C) had significantly higher final plant stand compared to CruiserMaxx 0.31 oz/CWT (B), Aprovia 0.75 l/a (C). Two treatments including: Emesto silver 0.31 fl oz/cwt (B) + Serenade 1 qt/a (C) + Velum prime 237.5 g ai/ha (C) + Luna tranquility 409 g ai/ha (D), and CruiserMaxx 0.31 oz/CWT (B) + Elatus 7.7 oz/A (D) had significantly lower PED disease severity (111 DAP) compared to the non-treated control and Nimitz 3.5 pt/a (A), ADA 36230 13.4 pt/a (C), and Vydate 310 SL 725 g ai/ha (C) + Vydate 310 SL 362.4 g ai/ha (D) + Vydate 310 SL 362.4 g ai/ha (E) (Table 1). Two treatments including: Emesto silver 0.31 fl oz/cwt (B) + Serenade Soil 1 qt/a (C) + Velum prime 237.5 g ai/ha (C) + Luna tranquility 409 g ai/ha (D), and CruiserMaxx 0.31 oz/CWT (B) + Elatus 7.7 oz/A (D) had significantly lower RAUDPC values compared to the non-treated control. Moreover, there was five treatments that had a significantly lower RAUDPC value compared to ADA 36230 13.4 pt/a (C) (Table 1). There were numerical differences, but no treatments were significantly different in total, US#1 and B size yield (CWT) compared to the non-treated control (Table 1). There were three treatments that had significantly higher vascular discoloration compared to the non-treated control (Table 1). There was no significant difference in *Verticillium dahliae* mean CFU/g per plot pre-planting and RLN in Roots and Soil (1 Aug) compared to the non-treated control (Table 1). Quantitative PCR targeting *V. dahliae* DNA at 60 DAP found that Nimitz 3.5 pt/a (A); Nimitz 7 pt/a (A), Nimitz 3.5 pt/a (C) and Nimitz 7 pt/a (C) had higher levels of target DNA, indicating more PED colonization in the plant. There were three treatments that had significantly lower number of RLN in soil pre-planting (30 May) compared to the non-treated (Table 1). These treatments include: Nimitz 7 pt/a (A); Emesto silver 0.31 fl oz/cwt (B) + Serenade 1 qt/a (C) + Velum prime 237.5 g ai/ha (C) + Luna tranquility 409 g ai/ha (D), and Emesto silver 0.31 fl oz/cwt (B) + Velum prime 237.5 g ai/ha (C) + Luna tranquility 409 g ai/ha (D). No phytotoxicity was observed from any treatments.

Table 1. Effects of in-furrow, at planting, and foliar treatments on severity of Verticillium wilt and rate of disease progression.

Treatment and rate[a]	PED[b] 10 Aug 69 DAP[c]	PED 17 Aug 76 DAP	PED 24 Aug 83 DAP[e]	PED 31 Aug 90 DAP	PED 7 Sep 97 DAP	PED 14 Sep 104 DAP	PED 21 Sep 111 DAP	RAUDPC[d] 0 – 111 DAP
1. Non-Treated	2.68	9.37	15.81 abc	26.58 bcd	60.94 abc	87.11 a	95.01 ab	0.418 a-d
2. Nimitz 3.5 pt/a (A)	5.60	9.37	15.49 abc	40.85 ab	64.45 ab	91.80 a	97.15 a	0.477 ab
3. Nimitz 7 pt/a (A)	4.68	3.51	13.55 bcd	18.87 cde	32.81 de	56.25 b-e	93.16 ab	0.300 cde
4. Nimitz 3.5 pt/a (C)	4.68	15.23	16.09 abc	37.00 abc	52.35 bcd	69.14 a-d	89.16 abc	0.416 a-d
5. Nimitz 7 pt/a (C)	4.68	17.56	22.47 ab	43.64 ab	58.20 abc	69.15 a-d	93.42 ab	0.448 abc
6. ADA 36230 6.75 (C)	4.68	10.54	34.14 a	40.85 ab	50.00 bcd	71.88 abc	94.28 ab	0.446 abc
7. ADA 36230 13.4 pt/a (C)	5.60	17.58	34.14 a	58.78 a	81.25 a	87.11 a	97.15 a	0.565 a
8. Vydate 310 SL 725 g ai/ha (C) Vydate 310 SL 362.4 g ai/ha (D) Vydate 310 SL 362.4 g ai/ha (E)	2.68	5.27	15.81 abc	34.14 abc	54.68 bcd	81.25 ab	95.97 ab	0.413 bcd
9. Emesto silver 0.31 fl oz/cwt (B) Serenade Soil 1 qt/a (C) Velum prime 237.5 g ai/ha (C) Luna tranquility 409 g ai/ha (D)	1.38	4.10	6.68 cd	15.81 de	23.44 e	45.31 de	79.78 c	0.228 e
10. Emesto silver 0.31 fl oz/cwt (B) Velum prime 237.5 g ai/ha (C) Luna tranquility 409 g ai/ha (D	4.68	11.72	15.81 abc	26.58 bcd	39.06 cde	50.00 cde	91.33 abc	0.321 cde
11. CruiserMaxx 0.31 oz/CWT (B) Elatus 7.7 oz/A (D)	2.22	2.93	5.60 d	11.31 e	19.92 e	42.97 e	82.01 c	0.209 e
12. CruiserMaxx 0.31 oz/CWT (B) Aprovia 0.75 l/a (C)	2.68	5.86	11.95 bcd	11.52 e	22.26 e	60.94 b-e	88.12 bc	0.284 de
Pr>F[e]	0.28	0.16	0.04	<0.01	<0.01	0.02	0.02	<0.01

[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] PED=Potato Early Die severity rated on a Horsfall-Barratt scale of 0 (no infection) to 11 (all foliage and stems dead). Ratings were converted to percentages.

[c] DAP = days after planting on 2 June.

[d] RAUDPC=relative area under the disease progress curve from planting to 111 days after planting.

[e] Means followed by same letter are not significantly different at $P = 0.10$ (Fishers LSD).

Table 2. Effects of in-furrow, at planting, and foliar treatments on percent plant emergence, rate of emergence, 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.

			Yield (CWT)						RLN[h]		
Treatment[a]	Plant stand[b] 46 DAP[c] (%)	RAUEPC[d] 0 – 46 DAP	Total	US #1	B Size	VD[e] (%)	Average CFU/g of Soil[f] 30 May	TaqMan Assay (Ct-values)[g]	Soil 30 May[i]	Soil 1 Aug	Root 1 Aug
1. Non-Treated	70.5	0.677	329.0	260.8	67.3	33	5.7	29.4	10.6 ab	8.2	1.5
2. Nimitz 3.5 pt/a (A)	76.1	0.721	388.0	312.3	75.1	58	2.3	19.1	4.4 bcd	3.5	0
3. Nimitz 7 pt/a (A)	74.2	0.715	345.0	274.4	67.2	55	5.6	18.6	2.2 d	3.8	1.5
4. Nimitz 3.5 pt/a (C)	77.4	0.736	282.3	218.8	63.3	53	4.5	40.5	10.4 ab	7.3	1
5. Nimitz 7 pt/a (C)	81.5	0.782	304.0	232.8	70.4	53	4.1	19.0	8.5 abc	5.7	0
6. ADA 36230 6.75 (C)	71.9	0.719	361.7	300.4	60.4	58	3.2	23.6	2.3 cd	14.3	0.5
7. ADA 36230 13.4I/a (C)	77.2	0.747	271.6	205.7	63.4	63	1.4	30.7	2.4 cd	1.8	0
8. Vydate 725Iai/ha (C) Vydate 362.4 g ai/ha (D) Vydate 362.4 g ai/ha (E)	72.4	0.690	327.1	268.8	58.1	43	7.6	22.1	15.7 a	2.7	0.5
9. Emesto silver 0.31 fl oz/cwt (B) SereIe 1 qt/a (C) Velum prime 237.5 g ai/ha (C) Luna tranquility 409 g ai/ha (D)	69.4	0.665	292.6	228.4	63.9	65	3.8	22.9	2.2 a	3.9	0
10. Emesto silver 0.31 fl oz/cwt (B) Velum prime 237.5 g ai/ha (C) Luna tranquility 409 g ai/ha (D	72.3	0.691	295.0	239.7	54.2	38	1.7	34.6	1.6 d	3.3	0.5
11. CruiserMaxx 0.31 oz/CWT (B) Elatus 7.7 oz/A (D)	69.2	0.670	363.0	291.8	69.7	63	5.1	25.9	4.1 bcd	2.7	0
12. CruiserMaxx 0.31 oz/CWT (B) Aprovia 0.75 l/a (C)	64.7	0.621	285.5	218.2	66.9	55	6.1	28.8	2.5 cd	2.3	0
Pr>F[i]	0.81	0.76	0.33	0.24	0.66	0.31	0.76	NA[j]	0.06	0.60	0.34

[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 25 ft rows per plot.
[c] DAP = days after planting on 2 June.
[d] RAUEPC=relative area under the emergence progress curve from planting to 46 days after planting.
[e] VD=Vascular discoloration of the stem end; percentage calculated from 10 tubers.
[f] CFU=colony forming units seen on selective *Verticillium dahliae* media.
[g] 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.
[h] RLN=root lesion nematode, *Pratylenchus penetrans.*
[i] Means followed by same letter are not significantly different at P = 0.10 (Fishers LSD).
[j] NA=not applicable.

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, 2018

A field trial was established 10 May (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 May 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 split-block design with four replications (4-row 50 ft plots) was used and treatment plots consist of the following crop rotations: 1) Potato (2018-21); 2) Corn (2018), Potato (2019), Corn (2020) and Potato (2021); 3) Corn (2018-19) and Potato (2020) and Corn (2021); and 4) Corn (2018-2020) and Potato (2021). The split-block included organic and inorganic fertilizer treatments. All crop management (irrigation, fertilization, insects, weeds, nematodes, and disease control) was per conventional grower practices. Each plot consisting of four 50-ft-long rows spaced 34 in. apart with tubers 10 in. apart in the row. A 20 ft non-planted alley separated plots. Foliar diseases were managed with Koverall at lb/A (wk. 1), Koverall at 2 lb/A (wks. 2, 6, 8, 9, 10), Manzate Pro Stick at 2 lb/A (wk 3), Echo 720 at 1.5 pt/A (wks. 4, 5), Equus 720 at 24 oz/A (wk. 7). Weeds were controlled by cultivation and with Linex 4L at 24 oz/A + Brawl II at 16 oz/A 15 and 28 days after planting (DAP), Select Max at 25 oz/A + R.O.C at 1 gal/A 63 DAP, Select Max at 25 oz/A + R.O.C at 1 gal/A + Matrix at 1 oz/A 92 DAP and Matrix at 1 oz/A 113 DAP. Insects were controlled with Admire Pro Systemic Pro 7 oz/A at planting, Besiege at 9 oz/A and 56 DAP and Coragen at 6.8 oz/A 84 DAP. Vines were killed with Reglone 2EC on 5 Sep (118 DAP). Plant stand was rated 38 DAP and percent emergence was calculated. Plots (1 x 50-ft row) were machine-harvested on 9 Oct (152 DAP) and individual treatments were weighed and graded. 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 152 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 Oct. Average daily air temperature (ºF) was 68.3, 72.2, 71.1, 64.2 and 48.6 (Jun, Jul, Aug, Sep and Oct respectively) and the number of days with maximum temperature >90ºF over the same period was 0 for each month except June with 2 days and July with 5 days. Average daily relative humidity (%) over the same period was 70.6, 66.8, 72.2, 76.9 and 76.2. Average daily soil temperature at 4 in. depth (ºF) over the same period was 69.1, 81.1, 76.9, 72,4 and 54.3. Average daily soil moisture at 4 in. depth (% of field capacity) over the same period was 35.0, 31.0, 32.0, 38.0 and 38.0. Precipitation (in.) over the same period was 2.05, 1.21, 5.4, 2.6 and 5.24”. Plots were irrigated to supplement precipitation to about 0.1 in./A/4 d period with overhead sprinkle irrigation.

Results

The 2018 growing season provided environmental extremes of excessive moisture in Aug and Oct 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. Treatments were not significantly different in emergence, total, US#1 B-size tubers yield in hundred-weight per acre (CWT) and incidence of common scab. There was a significant difference in severity of common scab between treatments.

Treatment and rate[a]	119 (DAP)[b,c] Yield (CWT)[d] Total	US #1	B Size	Scab Incidence	Scab Severity[e]	% Emergence
Potatoes, PPPP Inorganic Gypsum 1000 lb/A (A) K_2O 0-0-62, 150 lb ai/A (A) 10-34-0, 20 gal/A (B) K_2O Liquid 23 gal/A (B) AS 21-0-0-24, 82 lb ai/A (C) Urea 46-0-0, 60 lb ai/A (D) Urea 46-0-0, 60 lb ai/A (E)	168.3	155.9	12.4	100	81.6 a	86.5
Potatoes, PPPP Organic Herbrucks, 2 ton/A (A) Gypsum 1000 lb/A (A) K_2O 0-0-62, 129 lb ai/A (A) 10-34-0, 10 gal/A (B) K_2O Liquid 23 gal/A (B) AS 21-0-0-24, 35 lb ai/A (C) Urea 46-0-0, 35 lb ai/A (D) Urea 46-0-0, 35 lb ai/A (E)	210.9	187.5	23.4	100	72.0 b	85.8

[a] Application time; A=Pre-planting/pre-plant incorporated; B= In-furrow at planting; C=2” emergence; D=banded at hilling; E=7-10 days after hilling.
[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).

Entomology Research Report to the
Michigan Potato Industry Commission

Project Title: Determining insect and disease impacts on potatoes and developing strategies for sustainable management in the face of extreme weather events

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Summary of Problem

Models that forecast pressure of insect pests and crop diseases 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 potato and other crops. These models are currently not built to account for extreme weather events like droughts and 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 weather, then they will become inaccurate, making management of insect pests and crop diseases more difficult and costly.

A growing number of studies have examined the effects of extreme temperatures and drought on crops, crop diseases, and insect pests, but such studies have only examined small changes in temperature averages[4]. Such studies have overlooked the potentially more important effects of brief but extreme weather events on crops, crop diseases, and insect pests[5]. Our research project uses a set of lab and field experiments to reveal how extreme heat events influence the interaction between two key pests on potato: Colorado potato beetle (*Leptinotarsa decemlineata*) and the fungal pathogen *Alternaria solani*, which causes early blight. The product of this research will be the key initial steps towards improved potato pest forecasting models that accurately predict pressure from insect pests and crop pathogens in the face of extreme weather.

Research Objectives

1a. Measure effects of heat waves on field colonization by Colorado potato beetle, including potato defoliation and yield
1b. Measure effects of heat waves on field survival and growth of Colorado potato beetle on potato, including potato defoliation and yield

2. Measure effects of heat waves on interactions between early blight, Colorado potato beetle, and potato, including infection, spread, and yield in the field

Methods

1a. Measure effects of heat waves on field colonization by Colorado potato beetle, including potato defoliation and yield

In April 2018, Atlantic seed potatoes were cut into 2-2.5 ounce seed pieces using a seed cutting machine. These pieces were then kept in a refrigerated at 55ºF until planting. On April 25 the seed pieces were planted in rows 30 inches wide and spaced 10 inches between plants at the Montcalm Potato Research Farm. This section of field has been in continual potato production for approximately 10 years and has been used for pesticide trials and other Colorado potato beetle related experiments. There were no insecticides used on these plants during the experiment. The field was fertilized and treated with weekly fungicide applications as per industry standard for the course of the experiment.

__Figure 1__. Heat wave cages at the Montcalm potato farm in 2018.

Over the summer from early July to mid-August, three heat waves that lasted four days and four nights were simulated over multiple five-foot sections of single rows of potato plants. The heat waves were simulated using five by five foot pyramidal open top chambers constructed of wood and 6 mil greenhouse plastic (Fig. 1). These chambers were fitted with 300-watt ceramic heaters that were turned on at dusk and off at dawn to maintain elevated plant canopy temperatures. The electric heaters were powered by two Predator 8500 watt generators.

There were a total of 9 blocks down the length of the field. Each block consisted of 24 five by five foot plots, two rows of 12 plots with a buffer row between them. The control and heat treatments alternated down each row. For each heat wave event three blocks were randomly selected. Two of the three blocks received heat wave treatments via chambers fitted with ceramic heaters, these plots experienced both day and night time heating. The other block had chambers without ceramic heaters, these plots only experienced daytime heating. One single stem of a plant near the center of each plot was marked with a flagging tape and stem length of this plant was recorded prior to and 1 week after the heat wave. We designated the inner most 30” section of the row within the plot as our study plants. The total number of stems and total number of plants were recorded for this 30 inch section in every plot. The amount of defoliation for this section was estimated for every plot pre and post heat wave. Colorado potato beetle presence was measured for this section by recording the number of egg masses, recently hatched larvae, small larvae, large larvae, and adults both before, at the end of, and one-week post heatwave.

Leaf temperatures of the plant canopy within each plot were recorded via a digital infrared thermometer on the third day of the experiment between noon and one pm. The soil surface temperature as well as the soil temperature at four inches below the surface were also recoded at the same time. Night time canopy and soil temperatures were recorded on the morning of the fourth day from 4 am to 6am just prior to sunrise. Pendant hobo data loggers were fitted with solar shields and placed within the canopy of all 3 blocks during heat wave experiments. Each block received at least four data loggers, two in control and two in the heat-treated plots. Two of the data loggers were capable of recording humidity as well as temperature. These temperature and humidity data were recorded to document the effectiveness of our heat wave treatments.

In late August 2018, all potatoes within the innermost 30" section of each plot were dug up by hand. These were transported back to MSU main campus and stored at 37 ºF. Approximately one month later, the potatoes were assigned a scab rating from 0-5 (0 = no scab and 5 = > 50% of tuber covered with pitted lesions) and sorted into standard potato size classes (B's < 1 7/8", A's 1 7/8" – 3 ¼", and Oversize > 3 ¼"). After sorting, potatoes with deformities, like growth cracks, misshapenness, or scab ratings of 3.5 or higher were picked out. The remaining potatoes were again counted and weighed to estimate the marketable yield of each size class in each plot. The data was then analyzed and processed in R for statistical significance.

1b. Measure effects of heat waves on field survival and growth of Colorado potato beetle on potato, including potato defoliation and yield

Atlantic seed potatoes were sourced from Marker's Farm (Michigan) and stored at 37 ºF until time of seed cutting. Potatoes were cut into 2-2.5 ounce seed pieces one week prior to planting. After cutting the pieces were stored in a humid dark room at 55 ºF. There were two rounds of planting at the Kellogg Biological Station (KBS), first planting occurred on May 25, 2018 and second planting occurred on June 8, 2018. Seed pieces were planted 10 inches apart in rows spaced 30 inches apart. Planting dates alternated in every row across the field. Each plot had both age classes of plants. Heat wave treatments were conducted in the same manner as the above experiment but there were two rows of plants within each chamber. Five Colorado potato beetle larvae were placed on the plants and were left to feed on the plants for two weeks. During this time the larvae were exposed to heat waves for 4 days and 4 nights using the cages and infrared heaters. After two weeks the larvae were removed from the plants, survival, larval stage and larval weight were recorded along with potato yield.

2. Measure effects of heat waves on interactions between early blight, Colorado potato beetle, and potato, including infection, spread, and yield in the field

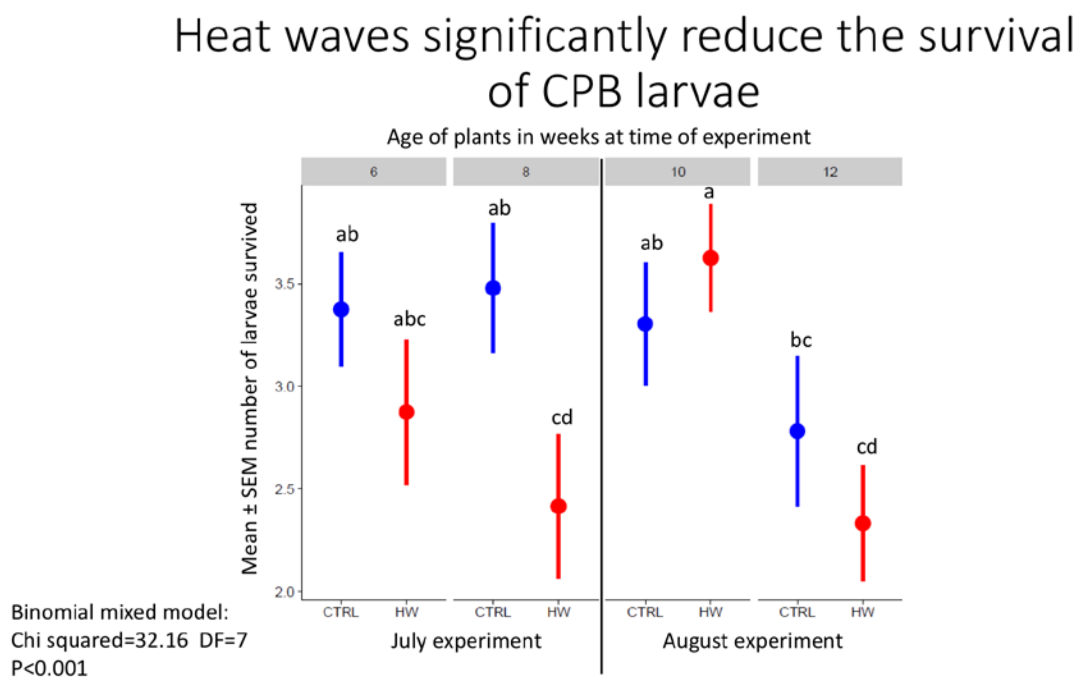
We were able to infect plants in the field with early bight and have conducted a preliminary experiment that allowed us to learn to do the artificial infections, handle plants so that control and infected plants can be grown in the same experiments and we also learned to evaluate disease symptoms. We will continue to work on experiments incorporating early blight into our work on heat waves.

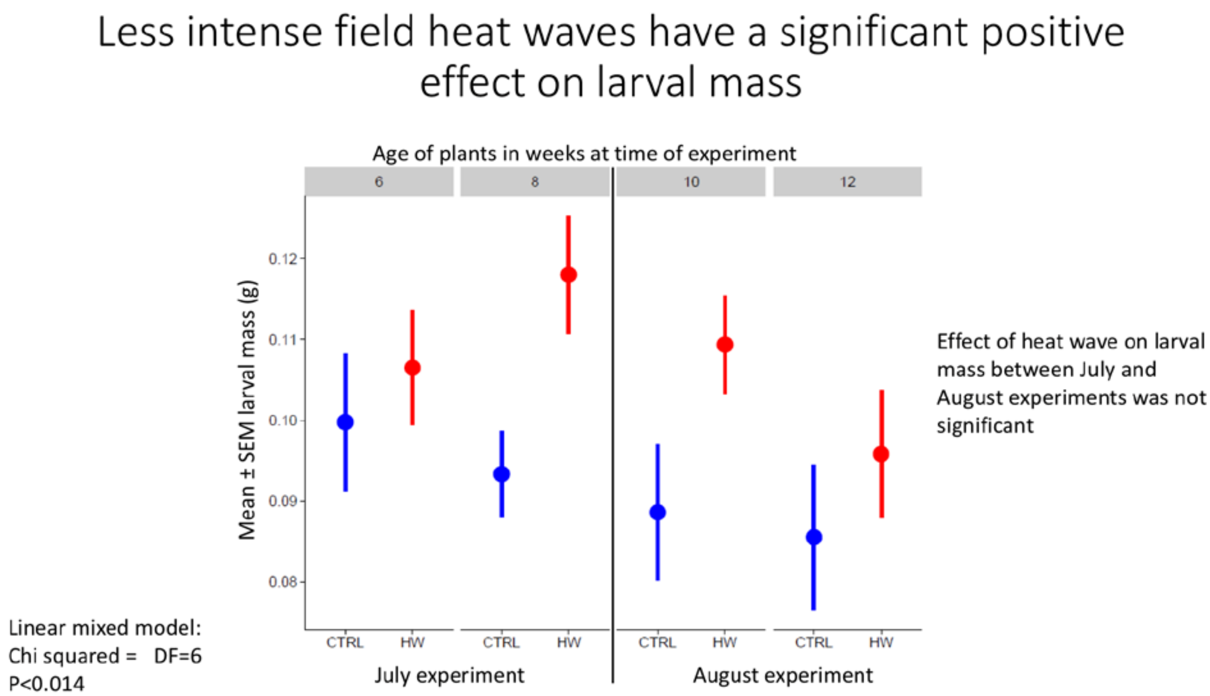
Results and Discussion

We have successfully completed the field component of our proposed project. We are currently analyzing all collected data; we have several important preliminary results to report.

Our warming treatments increased temperatures on potato plants by 10-15ºF during the day and 10ºF during the night. The magnitude and 24-h extent of our warming treatments represents an important advance over most previous warming studies. Previous climate variability studies have tended to warm plants only during the day, which is not an accurate representation of warming, and have warmed to lower maximum temperatures, accounting only for increases in average temperatures and not representing extreme events. These methods allowed us to gain novel insights into how extreme heat events will influence potato production and pest control, and we look forward to continuing to use these methods on potato in the field for future field seasons.

Our data indicate that heat waves, brief extreme high temperature events, reduce potato yield and lead to larger Colorado potato beetle larvae, but those Colorado potato beetle larvae have lower survival.





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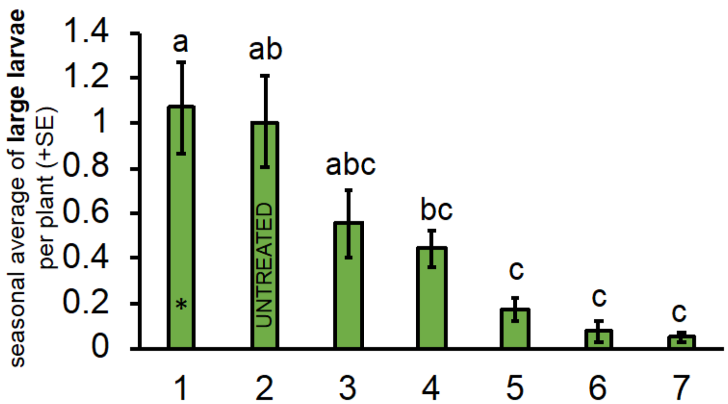
Colorado potato beetle insecticide trial - 2018

Potato planting: April 25, 2018
First foliar application (~50% egg hatch): June 6, 2018
Subsequent foliar applications: >1 per plant large larvae
Application: 30 psi, 30 gallons/A



Note: Bars with the same letters are not statistically different from each other.

	Treatment	Application type	Rate (fl oz/A)
1	Sivanto Prime	Foliar (2x)	10.5
2	Untreated	-	-
3	Sivanto HL + R11 (surfactant)	Foliar (2x)	5.25
4	Admire Pro + R11 (surfactant)	Foliar (2x)	1.3
5	Ethos XB Exirel + NIS	In furrow Foliar (3x)	12.8 5
6	Verimark Gladiator + NIS	In furrow Foliar (3x)	13.5 19
7	Verimark	In furrow	13.5

NIS – non-ionic surfactant

*Sivanto Prime (TRT 1) is a newer insecticide mainly for leafhopper control; leafhopper data is not reported here since we found very few of them during our trial.

Verimark, Exirel – cyantraniliprole (28), FMC
Ethos, Gladiator – pyrethroid (3), FMC
Sivanto, Admire Pro – neonicotinoid (4), Bayer

In 2018, the Vegetable Entomology Program conducted an insecticide trial that included already registered products as well as new products such as Sivanto HL (see figure above). The experiment was set up at the Montcalm Potato Research farm with four replications in 20 foot long plots, 3 rows wide. The insecticide applications were either made at planting (in furrow) or were foliar applications or a combination of the two applications types. Applications were made with a hand held CO_2 sprayer at 30psi, 30 gallons/A, using a single flat fan nozzle directed at a row of potatoes. Potatoes were planted in April 2018 and the first foliar applications were made at 50% Colorado potato beetle egg hatch. Subsequent foliar applications were made at 1 large larva per plant threshold. Five plants per plot were visually checked for all Colorado potato beetles and leafhoppers weekly until potatoes started declining at the end of the growing season. We found that Treatments 4-7 in the table above had significantly lower Colorado potato beetle pressure than the untreated control, but the treatments containing Sivanto did not differ statistically from the untreated control. Leafhoppers occurred at very low numbers in our trial in 2018, therefore statistical analysis was not possible.

Evaluation of foliar fungicides to manage late blight of potato in Michigan, 2018.

Jaime Willbur and Chris Bloomingdale
Dept. Plant, Soil and Microbial Science, Michigan State University

A fungicide efficacy trail was established at the Michigan State University Plant Pathology Farm in Lansing, MI. The objective of this trial was to compare the levels of late blight control provided by commercially available fungicides. To achieve this objective, a randomized complete block design was used, which was replicated four times. Potato seed was cut from US#1 'Snowden' tubers into 2 oz pieces, and allowed to suberize for 5 d before planting. To mitigate risk of late blight to commercial crops, planting was delayed until 6 Jun, to offset trial maturity for intended inoculation. Furrows were mechanically opened, so that seed could be hand planted. Plot dimensions were 4 rows wide, on 36-in. row spacing, and 20 ft long with 10-in. seed spacing. Two spreader rows of the highly susceptible variety 'Atlantic' were planted as borders along the trial. After planting, furrows were mechanically closed. Standard grower practices were followed to manage the trial and non-target pests. First fungicide applications occurred on 24 Jul, and were repeated weekly until 13 Sep. A CO_2 powered backpack sprayer, equipped with two TJ 8004XR flat fan nozzles and operating at a boom pressure of 24 psi, was used to apply fungicides at 15 gal/A. Inoculations were postponed until 15 Aug, pending an earlier in-state detection. At sunset on 15 Aug, liquid *P. infestans* inoculum (3.6×10^3 spores/mL) was applied using the previously mentioned spray equipment. Disease progression was recorded daily for the first 2 weeks after inoculation, then recorded weekly. In-field sprinklers were run late morning and late afternoon daily to extend periods of leaf wetness. The trial was not irrigated for 24 hr after applying treatments. Vines were removed by hand 9 Oct, and the center two rows of each plot harvested 12 Oct. Potatoes were washed and the marketable yield (cwt/A) determined. A general linear mixed model procedure was used to conduct the ANOVA and mean separations at $\alpha=0.05$.

Disease incidence was not significantly different among treatments in either the lower or upper canopy ($P>0.05$). Additionally, no differences were detected in disease severity of the lower or upper canopy ($P>0.05$). Disease incidence was overall low in the trial. The greatest mean disease incidence was 3.8% in the upper canopy and 0.5% in the lower canopy, both of these values were from the non-treated control. The mean severity was <1% in both upper and lower canopy. Marketable yield (cwt/A) did not differ among treatments. The range of mean yield was 267.0-385.1 cwt/A, with the lowest mean recorded in the non-treated control. Despite irrigation, the overall hot and dry Aug inhibited disease establishment. Initial disease ratings showed relatively high disease establishment, however, disease levels stalled and fluctuated with the hot, dry bouts. The overall low disease pressure made assessing the efficacy of the tested fungicides difficult. No significant differences were detected, but this is believed to be due to the unfavorable environmental conditions for the pathogen.

No.	Treatment and Rate/A	Upper Canopy DI (%)[z, y]	Upper Canopy DS (%)[x]	Lower Canopy DI (%)	Lower Canopy DS (%)	Marketable Yield (cwt/A)
1	Non-treated Control	3.8	0.05	0.5	0.02	267.0
2	Manzate Max 1.6 qt	0.0	0.00	0.1	0.01	385.1
3	Bravo Weather Stik 1.5 pt	0.0	0.00	0.0	0.00	364.3
4	Oranil 6L 1.5 pt	0.3	0.00	0.0	0.00	348.0

[z] Disease incidence (DI) reported as a visual estimate of the percent plants in the plot exhibiting signs/symptoms.
[y] Column values followed by the same letter are not significantly different based on Fisher's Protected LSD ($\alpha=0.05$); if no letter, then the effect is not significant.
[x] Disease severity (DS) reported as a visual estimate of the percent leaf area of infected plants showing signs/symptoms.

Evaluation of table potato variety and fungicides to manage late blight of potato, 2018.

Jaime Willbur and Chris Bloomingdale
Dept. Plant, Soil and Microbial Science, Michigan State University

Plots were established at the Michigan State University Plant Pathology Farm in Lansing, MI. A split plot design, replicated four times, was used to investigate the effects of potato variety and foliar fungicide on managing late blight. Three Russet varieties were used in this study: Burbank, Norkotah, and Payette. Potato seed was cut from US#1 tubers into 2 oz pieces, and allowed to suberize for 5 d before planting. To mitigate risk of late blight to commercial crops, planting was delayed until 6 Jun, to offset trial maturity for intended inoculation. Furrows were mechanically opened, so that seed could be hand planted. Plot dimensions were 12 ft (four rows on 36-in. row spacing) by 20 ft, and planted with 16-in seed spacing. Two spreader rows of the highly susceptible variety 'Atlantic' were planted as borders along the trial. After planting, furrows were mechanically closed. Standard grower practices were followed to manage the trial and non-target pests. The trial was split by variety, with each variety having plots with a non-treated or a Bravo Weather Stik treatment. First fungicide applications occurred on 24 Jul, and were repeated weekly until 13 Sep. A CO_2 powered backpack sprayer, equipped with two TJ 8004XR flat fan nozzles and operating at a boom pressure of 24 psi, was used to apply fungicides at 15 gal/A. Inoculations were postponed until 15 Aug, pending an earlier in-state detection. At sunset on 15 Aug, liquid *P. infestans* inoculum ($3.6x10^3$ spores/mL) was applied using the previously mentioned spray equipment. Disease progression was recorded daily for the first two weeks after inoculation, then recorded weekly. In-field sprinklers were run late morning and late afternoon daily to extend periods of leaf wetness. The trial was not irrigated for 24 hr after applying treatments. Vines were removed by hand 9 Oct, and the center 2 rows of each plot harvested 12 Oct. Potatoes were washed and the marketable yield (cwt/A) determined. A general linear mixed model procedure was used to conduct the ANOVA (α=0.05) and mean separations.

Plots were also monitored using hand-held (LC-RP Pro, Spectra Vista Corporation) leaf-clip reflectance probes with spectroradiometers and aerial hyperspectral cameras (Hyspex, NEO) mounted on a Cessna 180 aircraft. Spectral data collected by collaborators at the University of Wisconsin-Madison (Gevens, Townsend, and Gold). Hand-held reflectance data was collected daily from 15 Aug to 24 Aug. Visual late blight data was also recorded daily for this duration. Aerial data was collected on approximately 13 Aug, 18 Aug, 22 Aug, 30 Aug, and 12 Sep. Multispectral data was also collected through the Basso Lab using unmanned aerial vehicle with an onboard software development kit (SDK; Matrice, DJI Development). Drone flights were conducted on approximately 25 Jul, 17 Aug, and 12 Sep.

There was not a significant fungicide x variety treatment interaction (P>0.05) for any of the parameters analyzed, so fungicide treatments and variety were analyzed separately. No differences between non-treated and treated plants were detected in the lower or upper canopy (P>0.05), though treated plots had numerically lower index values than non-treated plots. The same can be said for the mean marketable yield of treatments. Variety used had no effect on disease (P>0.05), however there was a yield effect (P<0.01). Payette yielded the highest, with a mean value at least 80 CWT higher than Burbank or Norkotah. Spectral data will be analyzed by UW-Madison collaborators, and results will be provided to MSU when available. Samples of preliminary flight images are included. Despite regular irrigation before and after inoculation, the overall hot and dry Aug inhibited disease establishment. Disease ratings post inoculation showed relatively high late blight establishment, but disease levels declined with the hot, dry bouts. These overall unfavorable disease conditions limited the ability to assess interactions between these varieties and fungicide applications.

Table 1.

Treatment and Rate/A	Upper Canopy DX (%)[z, y]	Lower Canopy DX (%)	Marketable Yield (cwt/A)
Non-treated Control	0.009	0.02	257.96
Bravo Weather Stik 1.5 pt	0.006	0.00	268.91

[z] Disease Index (DX) was calculated by multiplying the disease incidence (0-100%) by the severity (0-100), then dividing by 100.

[y] Column values followed by the same letter are not significantly different based on Fisher's Protected LSD (α=0.05); if no letter, then the effect is not significant.

Table 2.

Russet Variety	Upper Canopy DX (%)[z, y]	Lower Canopy DX (%)	Marketable Yield (cwt/A)
Burbank	0.00	0.02	191.4 c
Norkotah	0.01	0.00	259.2 b
Payette	0.01	0.02	339.7 a

[z] Disease Index (DX) was calculated by multiplying the disease incidence (0-100%) by the severity (0-100), then dividing by 100.

[y] Column values followed by the same letter are not significantly different based on Fisher's Protected LSD (α=0.05); if no letter, then the effect is not significant.

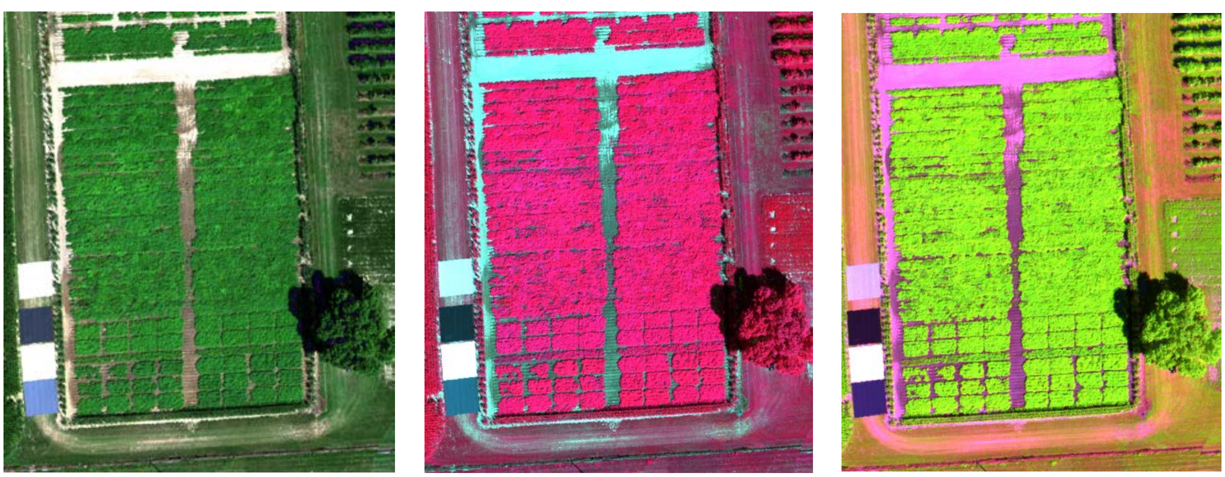


Figure 1. Preliminary images from aerial flights, differentially colored for contrast, data not analyzed.

Remote sensing to quantify spatial variability of crop nitrogen (N) status and optimize N fertilizer in potato fields
(Second year – continuation grant)

Michigan Potato Industry Commission Report
Bruno Basso, PhD.
University Foundation Professor
Department of Earth & Environmental Sciences
Michigan State University

Rationale

Potatoes are a high value crop that is imperative Michigan's agriculture economy. At the end of the day, yields are a vital measure of productivity and it is a factor that cannot be ignored. Improvements in areas such as fertility, irrigation, and pest/disease pressure can be mitigated through the use of remote sensing. Imagery collected remotely provide the necessary information to describe field-scale variability of plant growth during the growing season (Maestrini and Basso, 2018). Multiple layers of geospatial data are available to Michigan farmers that provide empirical clues regarding each year's harvest. The integration of these data is imperative in discerning the field's response to a dynamic system that includes differing trends in weather, variation in soil properties, and management changes.

Objectives

The overarching goal of this proposal is to evaluate how patterns of inherent spatial variability affect N uptake, N use efficiency (NUE), and potato yield in fields with potato rotations. These patterns were captured throughout the growing season with remotely sensed imagery from planes and unmanned aerial vehicles (UAVs) that included a multitude of sensors. Specific research objectives include:

1) To monitor in-season crop N status using remotely sensed imagery
2) To examine the relationships between plant chlorophyll content, spectral reflectance, N status, and crop yield at the field scale

Methodology

Field Descriptions

Two fields near Six Lakes, MI were selected for study in cooperation with Main Farms. The field "C9" is located in Montcalm County. The field is irrigated with two pivots and contains three dominant soil types for the 78.6 acre field. Tekenink-Elmdale loamy sands on 2-6% slopes are found in 62.2% of the field. McBride and Isabella sandy loams on 2-6% slopes (13.5%) and 6-10% slopes (11.7%) cover the remainder of the field. The field "C10" is immediately south of C9. It contains two pivots and two dominant soil types: McBride and Isabella sandy loams on 2-6% slopes (83.3%) and 6-10% slopes (11.5%) for a total of 62.2 acres. Yield data for both fields provided from a combine yield monitor was available for 2016 (wheat), 2017 (corn), and 2018 (corn) (Table 1). A wet spring in early 2018 delayed planting at several farms in the Montcalm area, and both fields were the among the last potato fields to be planted by the cooperator in 2018.

Yield Stability Zones
Yield monitor data collected from previous grain harvests provided necessary information for the fields to be classified by varying levels of productivity. These yield stability zones (YSZs) were created from a statistical analysis of differing trends within the field. YSZs were created for both C9 and C10 (Figure 1). Classifications for YSZs included high yielding and stable (HS), medium yielding and stable (MS), low yielding and stable (LS), and unstable (UN).

Nitrogen Management
Applications of N occurred four times throughout the growing season: pre-plant (urea), planting (liquid), hilling (liquid), and post-hill (both) (Table 2). The entire field was treated with uniform N (conventional), except for two (tactical) strips across the field. Tactical high was treated with an additional 25 lb N/ac at hilling and tactical low was treated with 25 lb N/ac less at hilling. The tactical treatments allow us to examine the sensitivity of the remotely sensed imagery with attention to the gradient of three levels of N applications.

Remote Sensing Imagery
Remotely sensed imagery was collected with a UAV and airborne service throughout the growing season. UAV images were captured with multiple sensors, including visible, infrared, and thermal wavelengths. These images were processed in a stitching software to create georeferenced orthomosaic reflectance panels that were used to calculate vegetation indices, including normalized difference vegetation index (NDVI), normalized difference red edge (NDRE), weighed difference vegetation index (WDVI), and ground cover (GC) (Table 3). UAV flights were made five times during the season. The first flight occurred before potatoes were planted (5/8). The remaining flights were made at multiple times throughout the season (Table 4).

Field Sampling
Soil and plant samples were collected during the growing season. Hand digs taken immediately before machine harvest were collected from 3 replicates of 7 feet at 20 different points throughout the field. These points were chosen based on different criteria: YSZ, tactical/conventional treatment, and imagery inconsistency. Tubers were graded into four categories: No. 1s, No. 2s, pickouts, and throw-aways. Before 2018, potato yields were estimated using two separate methods: 1) short sections of rows were dug up by hand and weighed; 2) trucks leaving the field were weighed and averaged for the area that was harvested. Both methods fail to capture a proper spatial resolution similar to the yield monitor found on most combine harvesters. For this year, a yield map was also created from a machine harvester after harvest was completed on 10/24/2018.

Results
For fields in potato production, center pivots are essential to providing enough rainfall for adequate potato growth. YSZs tend to follow similar patterns found with irrigated fields, while the spatial variability of yield in rainfed fields is more prevalent. HS zones dominate areas of the field where water is rarely limited (Figure 1). Further outside of the reach of the irrigator, water is unable to fully supply high growth of the plot and these zones are classified as MS. Finally, the headlands of the fields where compaction is more prevalent from implements turning around are classified as LS.

Remote Sensing
Remotely sensed imagery from the growing season captured similar trends of spatial variability in the WDVI, which allows for an accurate representation of the potato health before canopy closure. These images from the UAV show variability related to the spatial variation in the field (lower elevation) and slightly lower values in the tactical low treatment (Figures 2 & 3). The variability of the index was higher at each yield stability zone than each N treatment, confirming the importance of the YSZ classifications. On July 17th, there was a clear difference in index values at each of the three YSZs (Figure 4). The index reached complete saturation by August 3rd, emphasizing the importance in capturing these images before the plant canopy reaches peak greenness.

Yield and Nitrogen Use Efficiency
Hand digs and data interpolated from the harvester yield monitor contributed to an in-depth understanding of how potatoes use N across a diverse landscape. The areas within the reach of the irrigator fall into mostly HS and MS. Parts of the field near the border are found to be mostly LS and UN based on the YSZ analysis of grain yields. A yield map was created using harvest data collected by the harvester (Figure 5). At field C9, the highest yields in the field fell directly in line with the tactical high strip which received an additional 25 lb N/ac at hilling on July 3rd. The tactical low strip at the lower portion of the field also exhibited some of the lowest yields relative to the remaining portions of the field. Similarly, at field C10, the tactical high strip showed some of the higher yields relative to the rest of the field. The additional N applied in the tactical high strip correspond with increased yields, as seen in these maps. The NUE maps (Figure 6) reflect a similar pattern of spatial trends shown in the yield maps due to uniform concentrations of measured N across the fields. The yield maps from the harvester data are extremely valuable as they show large ranges of yield, varying from less than 200 to 550 cwt/ac, that are attributed to the inherent spatial variability of the fields rather than the tactical strips of varied N applications.

Conclusions
The yield data from a year of potatoes in a traditional rotation for a potato grower has been missing data in the past. New technology attached to the harvester now mimics the established yield monitors found in grain harvesters that have become extremely important. Fertility in potato production is also difficult due to the nature of their coarse textured soils and the inability to maintain high productivity without considerable amounts of supplemental N. Matching the plant demand with adequate supply is still a challenge; however, this study has shown that remote sensing can detect those subtle differences by using a gradient of multiple N scenarios.

Table 1. Fields of study in 2018.

Field Name	Yrs. of Yield Data	Cropping History	Field size (ac)
C9	3	wheat-corn-corn-potato	78.58
C10	3	wheat-corn-corn-potato	62.18

Table 2. N Management at both fields in 2018.

Treatment	Pre-Plant May 2 (lb N/ac)	Planting May 30 & June 2 (lb N/ac)	Hilling July 3 (lb N/ac)	Post-Hilling July 30 (lb N/ac)	Total N (lb N/ac)
Tactical – High (25 lb ↑)	46	59	95.4	33	233.4
Conventional	46	59	70.1	33	208.1
Tactical – Low (25 lb ↓)	46	59	44.7	33	182.7

Table 3. Remote sensing vegetation indices used in 2018.

Index	Equation	Description	Reference
NDVI	$ndvi = \frac{nir - red}{nir + red}$	Estimates LAI, biomass accumulation, vegetation presence	Millard et al. 1990
NDRE	$ndre = \frac{nir - red\ edge}{nir + red\ edge}$	Proxy for N concentration	Sharma et al. 2017
WDVI	$wdvi = nir_{canopy} - \left(\frac{nir_{soil}}{green_{soil}}\right) green_{canopy}$	Removes soil reflectance before plant canopy appears	Clevers, 1989
GC	$GC = 196.6\ x\ wdvi\ if\ wdvi < 0.29$ $GC = -8.05 + 228.5\ x\ wdvi\ if\ wdvi \geq 0.29$	Estimates ground cover amount	Bouman et al. 1992

Table 4. UAV flight dates.

Field	Flight Date
C9 & C10	5/08/2018
	7/02/2018
	7/17/2018
	8/03/2018
	9/05/2018

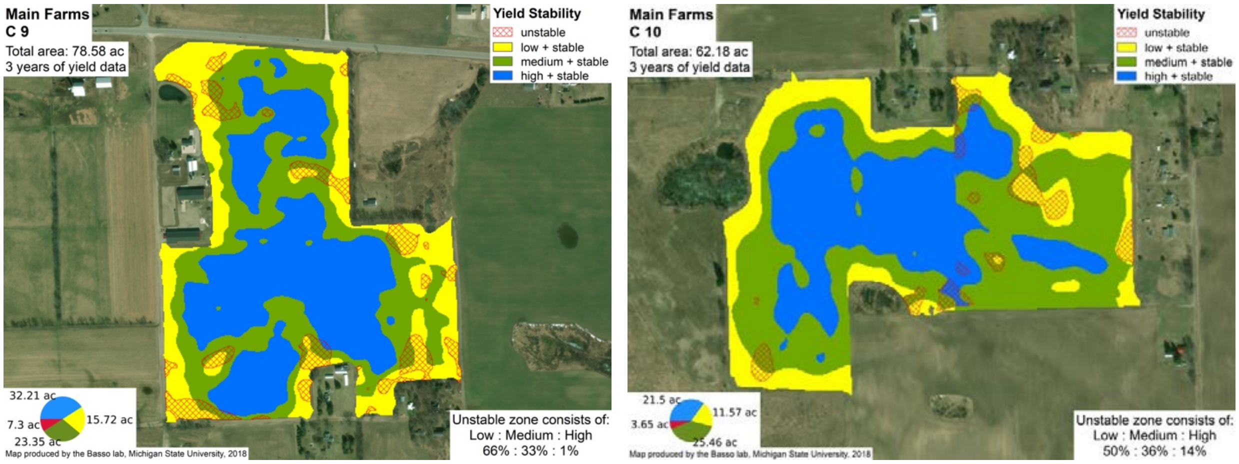


Figure 1. Yield stability maps for both fields of study in 2018.

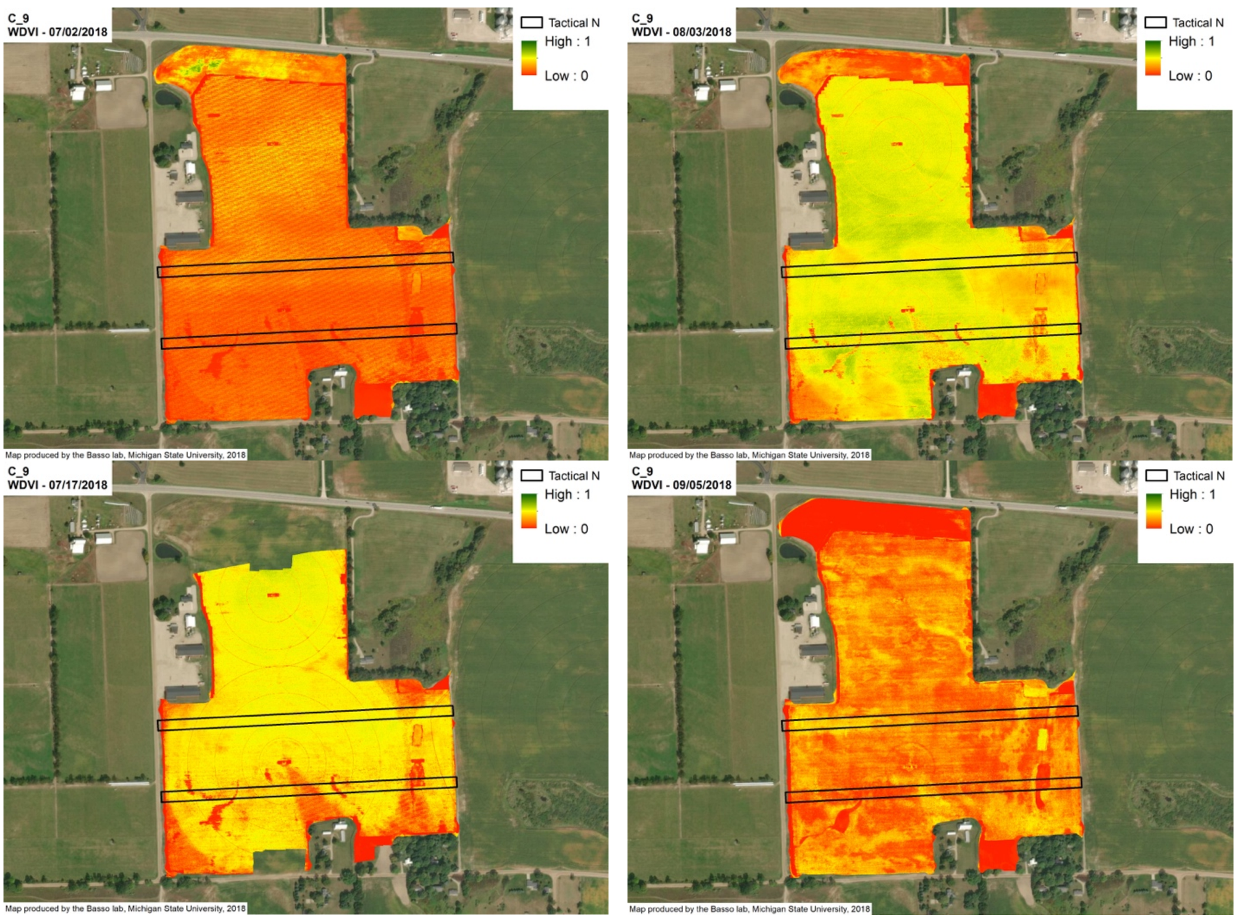


Figure 2. WDVI for C9 from July through September for 2018.

Figure 3. WDVI values at 3 dates for 3 yield stability zones (HS, MS, LS) and 3 N treatments (tactical high, conventional, and tactical low).

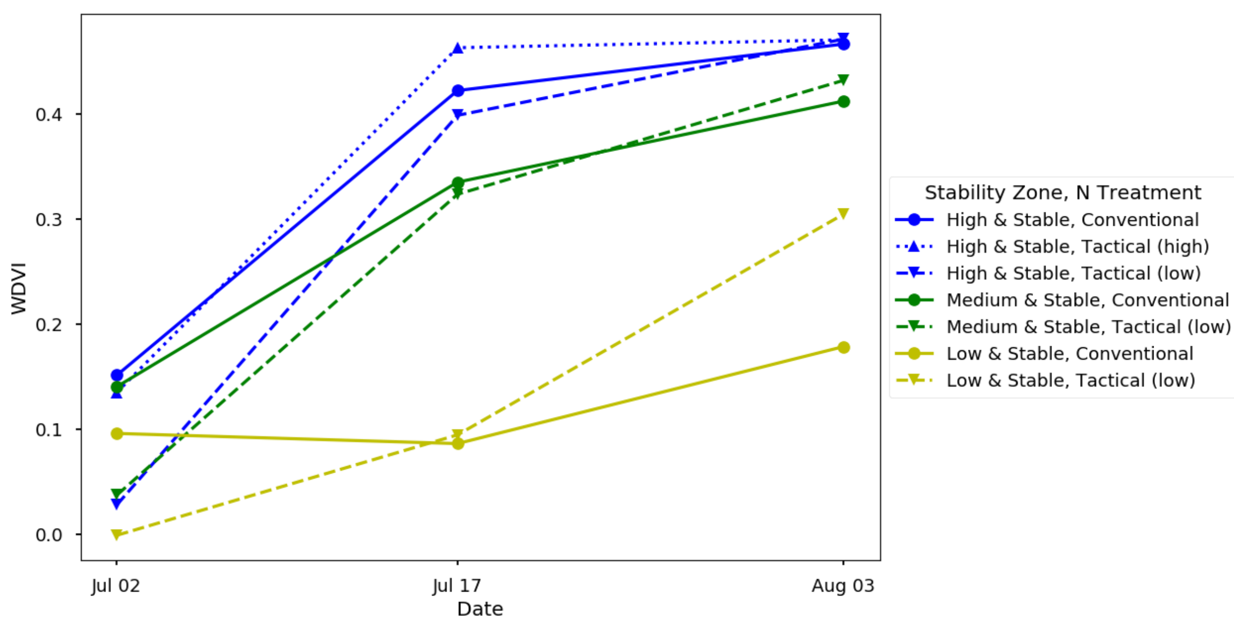


Figure 4. WDVI at 3 dates for 3 yield stability zones (HS, MS, LS) and 3 N treatments (tactical high, conventional, and tactical low).

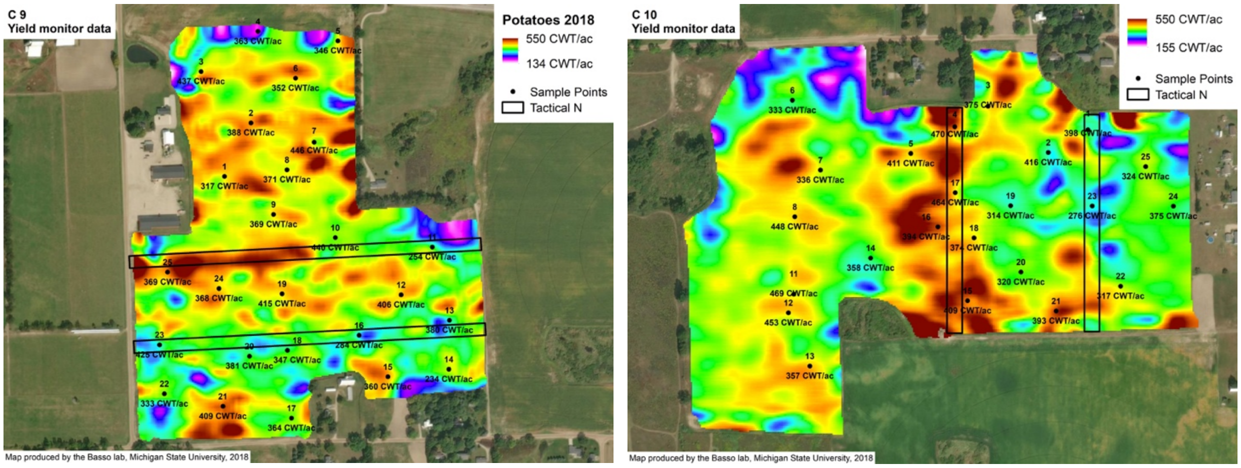


Figure 5. Yield map created from harvester data for fields C9 and C10.

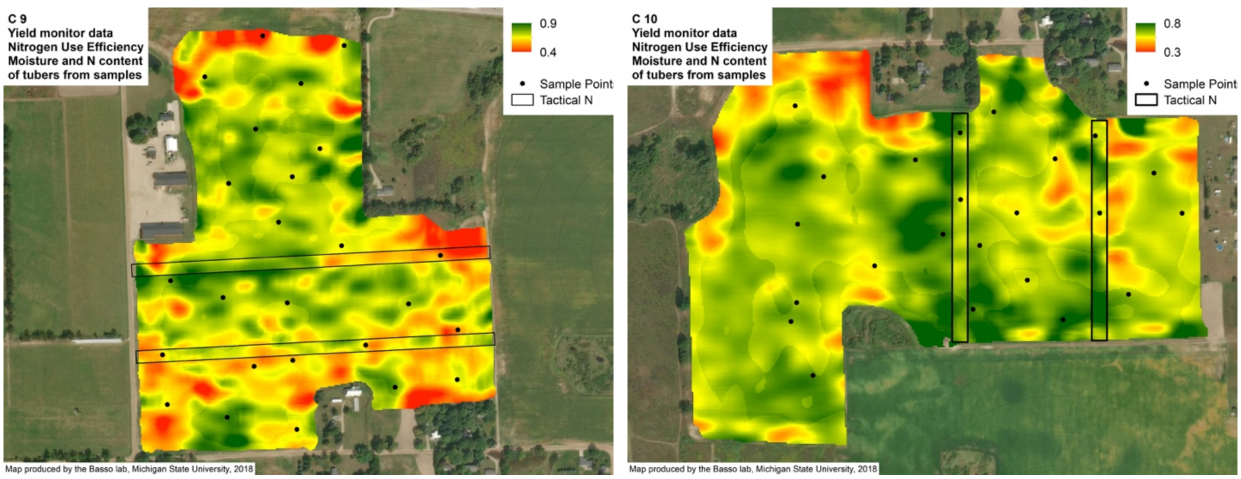


Figure 6. Nitrogen use efficiency maps for fields C9 and C10.

Evaluation of Potato Early Die Complex Management Using Custom Compost Blends and Nematicides

Two field trials were conducted in 2018; one at the Montcalm Research Center in Entrican, MI and the other at Walther's Farms in Cassopolis, Michigan to evaluate the effects of nematicides and compost/manures on potato early die complex. Ten treatments were tested at the Montcalm site which included: Untreated Control, Poultry Manure High (5 tons/acre), Poultry Manure Low (1.25 tons/acre), Layer Ash Blend High (5 tons/acre), Layer Ash Blend Low (1.25 tons/acre), Dairy Doo High (5 tons/acre), Dairy Doo Low (1.25 tons/acre), Vydate, and MeloCon (bionematicide), and Majestene (bionematicide). Composts and manures were applied 1 day prior to planting and plots were planted June 10th. Each treatment was replicated 4 times in 12'x50' plots. On September 24, one 23' row was harvested from each plot and subsequently weighed and graded to determine yield on a per acre basis. Yields at Montcalm were particularly low which we suspect is due to due to high disease pressure and frequent potato cropping in the same fields.

Plots at Walther's Farms were planted May 8, 2018 in 11'x 15' plots. Twenty treatments were tested and included: Untreated Control, Control with only neonicotinoids applied to seed piece, Control with only fungicides applied to seed piece, Control with fungicides and neonicotinoids applied to seed piece, Nimitz High (7pts/acre) Nimitz Low (5 pts/acre), Emesto Silver + Serenade + Velum Prime, Emesto Silver + Serenade + Velum Prime + Movento HL, Emesto Silver + Serenade + Velum Prime + Luna Tranquility, Q8U80 High + Vydate, Q8U80 High + 2 Vydate applications, Q8U80 Low + Vydate, Q8U80 Low + 2 Vydate application, Vydate, Velum Prime + Movento HL, Mocap, MeloCon, Layer Ash Blend Low (1.25 ton/acre), Layer Ash Blend High (5 ton/acre), Poultry Manure High (5 ton/acre). Q8U80 is an experimental product from Dow Dupont that is expected to be on the market in 2020 likely under the name Salibro. Again, all treatments were replicated four times. Furthermore, all treatments besides the Untreated Control, Control with neonicotinoids and control with fungicides were had seed pieces treated with neonicotinoids and fungicides. In furrow nematicide and compost/manure treatments were applied day of planting. On September 27, one 15' row was harvested from each plot, weighed and graded to determine yield on a per acre basis.

At both locations, data collected included nematode populations at pre-plant, two weeks post-plant, mid-season, and harvest, Verticillium populations within collected stems at midseason as well as within soil at two weeks post-plant and mid-season, plant growth, and yield. We are currently still processing nematode and Verticillium samples, but preliminary data is shown below.

Aside from field trials, we have been conducting lab trials to elucidate compost impacts on nematode populations and attempt to understand the mechanism that may be contributing to control.

The 2018 trials have demonstrated that some of these designer composts have high effectiveness in controlling root lesion nematode. In addition, some new nematicides are standing out in effectiveness. The role of neonicotinoids in nematode control is also a question we think is partly answered. We did not see them providing important control, but the fungicide associated with the seed treatment is believed to have reduced beneficial biocontrol fungi or had some other effect on biocontrol, as the untreated control had lower nematode numbers and higher yield. Of course, our proposal also generated new questions and we want to obtain an additional yield of data in order to provide good management recommendations to growers.

Results from these trials were recently presented at the Great Lakes Expo in Grand Rapids, Michigan in the form of a talk and poster (see attached posters). We have also presented results to directly to growers at the Presque Isle field day and the Montcalm Field Day. We intend on producing extension materials to provide recommendations to growers as well as publishing results in the coming year.

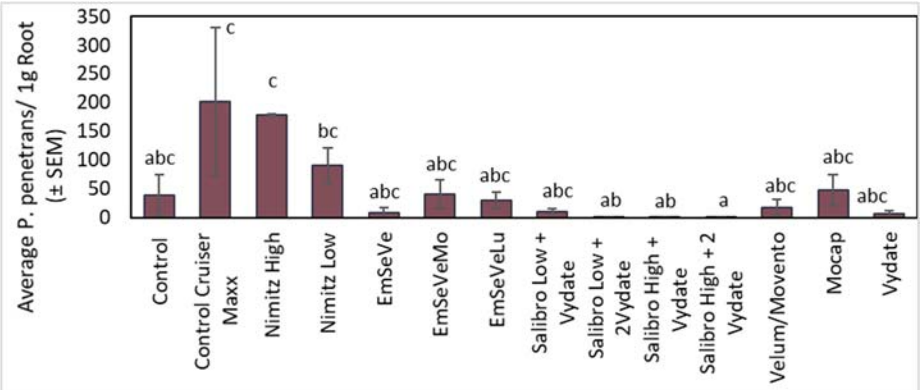


Figure 1. Average number of root lesion nematodes recovered per gram of root from mid-season root samples at Walther's. Error bars indicate the standard error of the mean. Treatments labeled with different letters are statistically different (Tukey HSD, α = .05)

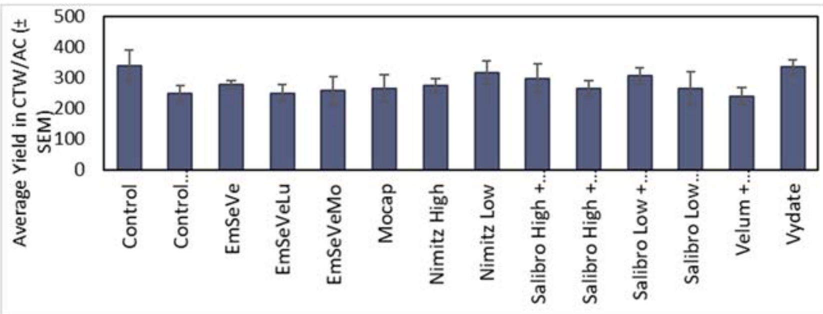


Figure 2. Average total yield in Century Weight per Acre (CTW/AC) from Walther's plots. Error bars indicate standard error of the mean. No significant differences were found (ANOVA, α= .05)

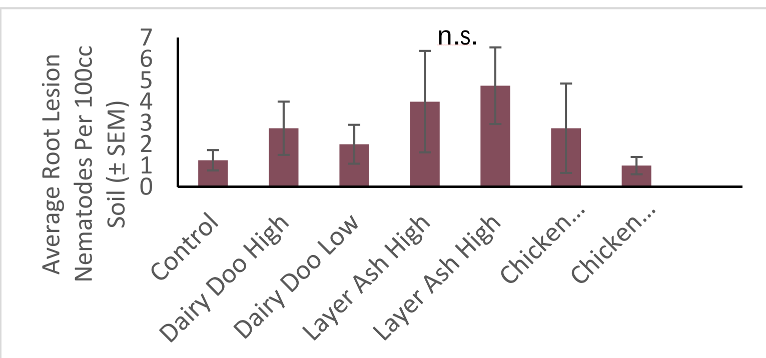


Figure 3. Average number of root lesion nematodes recovered per gram of root from mid-season root samples at Montcalm. Error bars indicate the standard error of the mean. No significant differences were found (ANOVA, α = .05)

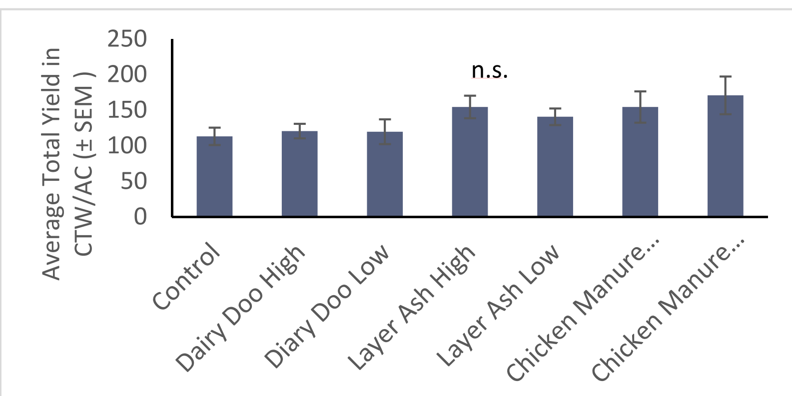


Figure 4. Average total yield in Century Weight per acre (CTW/AC) from Montcalm plots. Error bars indicate standard error of the mean. No significant differences were found. (ANOVA, α = .05)

CAN COMPOSTS HELP MANAGE ROOT-LESION NEMATODES IN POTATOES?

Emilie Cole and Marisol Quintanilla
Michigan State University

INTRODUCTION

Root Lesion nematodes (*P. penetrans*) feed on potato roots (fig. 1) increasing Verticillium wilt infection thus leading to Potato Early Die Complex which can severely impact yields. Traditional control tactics are predominately chemical including fumigants and nematicides. Although some are effective, these products do little to promote soil health. Literature has suggested that utilizing manure-based compost can reduce nematode populations, but results have been mixed. Compost is inherently quite variable leading our project to collaborate with a local compost producer with consistent products to determine their efficacy against root lesion nematodes in potatoes.

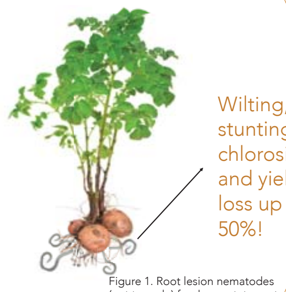


Figure 1. Root lesion nematodes (not to scale) feed on potato roots

OBJECTIVES

I. Determine which compost/manure provides optimal control of root lesion nematodes

II. Establish which compost/manure has the most efficacy at low rates

III. Determine if composts/manures are effective in a field setting

MEET THE COMPOSTS

- **Dairy Doo** – Composted Diary Manure
- **Dairy Doo w/ Spelt** – Composted Diary Manure w/ Spelt Hulls
- **Chicken Manure** – Pure Chicken Manure
- **Poultry Compost** – Composted Chicken Manure
- **Layer Ash Blend** – Composted Chicken & Dairy Manure w/ Wood Ash
- **Worm** – Red Wriggler Worm Castings
- **Control** – Play Sand

I. WHICH COMPOST IS MOST EFFECTIVE?

Methods

- The 7 products listed above were tested.
- 40 cc of each product were placed into 20 centrifuge tubes and inoculated with 200 root lesion nematodes (fig. 1a)

Figure 1. (a) Inoculating nematodes; (b) Modified Baermann Pan

- After 1, 2, 5 and 7 days 5 tubes from each treatment were placed in a modified Baermann pan (fig. 1b) to determine survival (fig. 2)

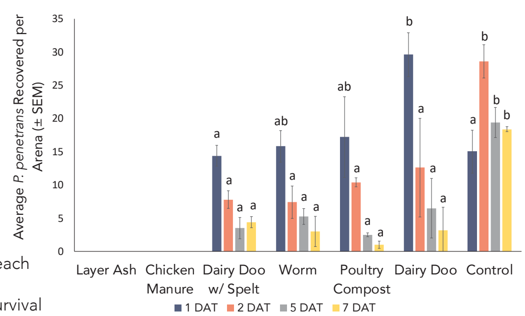


Figure 2. Average number of recovered nematodes per centrifuge tube separated by days after treatment (DAT). Treatments were analyzed by DAT . Treatments marked with different letters are significantly different (α=.05; Tukey HSD)

Results

- Both the Layer Ash and Chicken Manure Treatments recovered ZERO root lesion nematodes
- As time within the compost/manure progressed each treatment recovered fewer nematodes compared to control

II. WHICH RATE IS BEST?

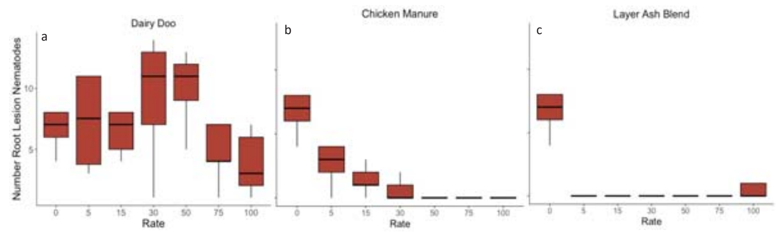


Figure 3. Boxplot representing the number of nematodes recovered from (a) Dairy Doo, (b) Chicken Manure (c) Layer Ash Blend at various rates of 0, 5, 15, 30, 50, 75 and 100% compost.

Methods

- Chicken Manure, Layer Ash Blend and Dairy Doo were tested at rates of 100, 75, 50, 30, 15 and 5% compost on a vol/vol ratio with sand. 100% sand served as a control
- The same methods from the previous experiment were used except arenas were left for 7 days.

Results

- Dairy Doo was variable in control suggesting it would be a poor nematicidal agent (Fig. 3a)
- Chicken manure had best results above 50% manure with moderate control below 50% manure (Fig. 3b)
- Layer Ash provided optimal control even at 5% compost making it a promising candidate for a nematicidal agent (Fig. 3c)

III. ARE COMPOSTS EFFECTIVE IN A FIELD SETTING?

Methods

- Russet Norkotah potatoes were planted at the Montcalm Research Center in early June.
- Dairy Doo, Layer Ash and Poultry Manure were tested at 1.25 tons per acre and 5 tons per acre against a non-treated control.
- Composts were spread one day prior to planting
- Soil was collected mid-August and nematode populations were determined
- Yields were determined by harvesting 23' from each plot.

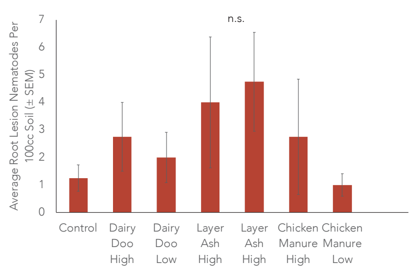


Fig 4. Average number of root lesion nematodes recovered from 100 cc of soil; n.s. indicates no significance (Tukey HSD; α = .05)

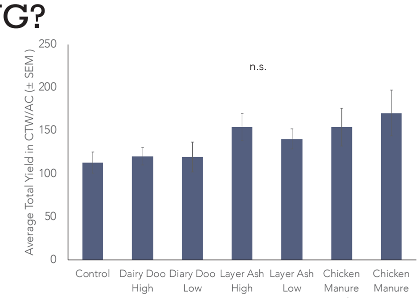


Fig 5. Average potato yield per plot in century weight per acre (CTW/AC); n.s indicates no significance (Tukey HSD; α = .05)

Results

- Plots treated with chicken manure at a low rate had fewer nematodes numerically, but overall field numbers were quite low and no statistical significances were found.
- Layer Ash applied at a high rate and chicken manure applied a low rate provided the highest yields, but no statistical significances were found.

SUMMARY

I. In a lab setting the Layer Ash Blend and chicken manure show promise in having nematicidal properties
II. The Layer Ash Blend reduced nematode populations at a rate of 5% compost
III. In the field, no significant differences were found but chicken manure at a low rate had the lowest nematode populations while Layer Ash at a high rate and chicken manure at a low rate had the highest yields.

Overall, compost has promising nematicidal effects but more field work needs to be done to determine efficacy in field situations.

ACKNOWLEDGEMENTS

We would like to thank Elisabeth Darling, Lauren Rodriguez, Brian Levene, Kristin Poley, and the Potato Outreach Program for all assistance along the way as well as Morgan Composting, the Michigan Potato Industry Commission and Project GREEEN for funding.

QUESTIONS/COMMENTS? Email me at coleemi1@msu.edu

COMPARING CHEMICAL OPTIONS TO CONTROL ROOT-LESION NEMATODES AND VERTICILLIUM WILT IN POTATO

Emilie Cole and Marisol Quintanilla
Michigan State University

INTRODUCTION

When present together in a potato field, root lesion nematodes (*Pratylenchus penetrans*) and the fungal pathogen *Verticillium dahliae* create what is known as Potato Early Die Complex. This complex causes potatoes to senesce prematurely ultimately reducing yields by up to 50%[1]. Historically management has included soil fumigants however regulations on these products are pushing growers to opt for alternatives such as nematicides. In this trial we tested twelve products with two controls to determine if they reduce Potato Early Die Complex incidence.

METHODS

Field Set-up

- 14 treatments (listed below) were tested in a complete randomized block design with four replications .
- Each plot (12' x 15') was planted with 4 rows of Russet Norkotah potatoes in early May

Verticillium Populations

- In early August, 10 stems were collected from each plot, plated on Bacto-Agar and left for two weeks. After this time, the number of infected stems was recorded.

Nematode Populations

- In late July, 1 gram of roots was collected from each plot (Fig 1). They were then washed and shaken in 1% bleach solution to extract the nematodes which were subsequently counted.

Yield

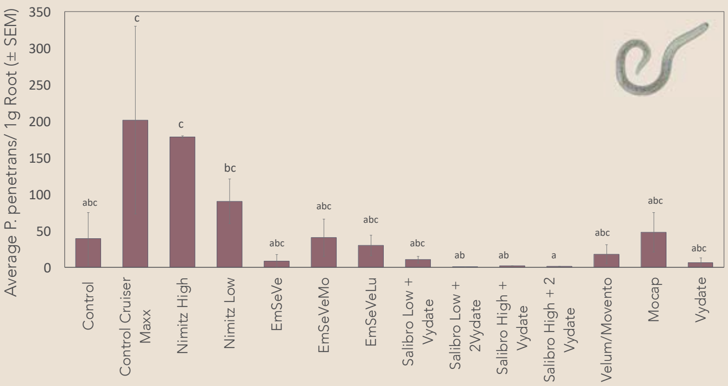
- 1, 15 foot row was harvested from each plot. Potatoes were then weighed in KG and converted to a per-acre scale in Century Weight per acre.

Figure 1. Brian Levene and Lauren Rodriguez collecting roots for nematode sampling.

TREATMENTS

Control | Control with Cruiser Maxx | Nimitz High (7oz/ ac) | Nimitz Low (5oz/ ac) | Emesto Silver, Serenade, Velum (EmSeVe) | Emesto Silver, Serenade, Velum, Movento (EmSeVeMo) | Emesto Silver, Serenade, Velum, Luna Tranquility (EmSeVeLu) | Salibro Low + 1 Vydate app. | Salibro Low + 2 Vydate app. | Salibro High + 1 Vydate app. | Salibro High + 2 Vydate app. | Salibro Low + 2 Vydate app. | Velum + Movento | Mocap | Vydate

NEMATODE POPULATIONS



- Both high rates of Salibro and the Low rate with two applications of Vydate had significantly fewer root lesion nematodes per gram of root compared to the Control with Cruiser Maxx.
- Vydate, Emesto Silver with Serenade and Velum also exhibited low populations of *P. penetrans*.

Figure 2.. Average root lesion nematodes per gram of root ± SEM. Treatments makred with different letters are significantly different (Tukey HSD, α = .05)

VERTICILLIUM POPULATIONS

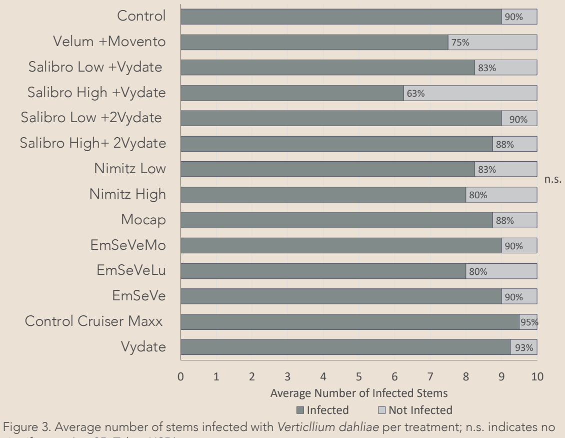


Figure 3. Average number of stems infected with *Verticllium dahliae* per treatment; n.s. indicates no significance (α=.05, Tukey HSD).

- No significant differences were found and all treatments had over 60% of stems collected infected with Verticillium dahliae.
- Plots treated with Salibro at a high rate with one application of Vydate had the lowest rate of infection, numerically.

YIELD

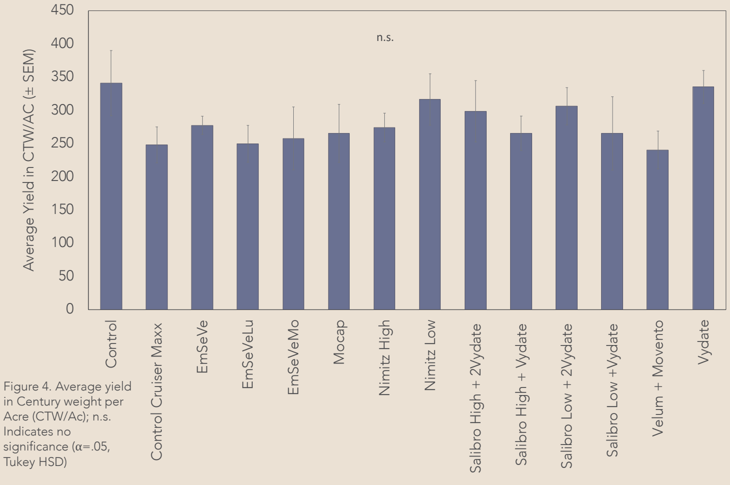


Figure 4. Average yield in Century weight per Acre (CTW/Ac); n.s. Indicates no significance (α=.05, Tukey HSD)

- No significant differences were found amongst treatments.
- Yields were highest within plots treated with Vydate, Nimitz Low (5 oz./ac), and the untreated control.

Figure 5. Potatoes on conveyor of harvester.

SUMMARY & FUTURE DIRECTIONS

- Salibro treated plots had the fewest nematodes per gram of root.
- Salibro at a high rate with one application of Vydate had the lowest rate of *Verticillium* infection.
- Overall yields were highest amongst Nimitz Low (5oz/ac) and Vydate treated plots but there were no significant differences between treatments.
- Overall, Salibro looks promising in controlling Potato Early Die Complex but more work needs to be done to solidify results.

ACKNOWLEDGEMENTS

We would like to thank Elisabeth Darling, Brian Levene, Kristin Poley, Lauren Rodriguez, and the Potato Outreach Program for technical assistance as well as Project GREEEN and the Michigan Potato Industry Commission for funding this project.

[1]Powelson and Rowe. Annu Rev Phytopatho. (1993)

QUESTIONS/COMMENTS? Email me at coleemi1@msu.edu

2017-2018 MICHIGAN POTATO DEMONSTRATION STORAGE ANNUAL REPORT MICHIGAN POTATO INDUSTRY COMMISSION

Chris Long, Coordinator, Trina Zavislan, and John Calogero

Introduction and Acknowledgements

Round white potato production for chip processing continues to lead the potato market in Michigan. Michigan growers continually 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, 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 sixteenth annual Demonstration Storage Report contains the results of the storage work conducted in the facility during the 2017-2018 storage season. Section I, “2017-2018 New Chip Processing Variety Box Bin Report”, contains the results and highlights from our 10 cwt. box bin study. Section II, “2017-2018 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 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 and John Crooks, Crooks Farms, Inc.; Brian Sackett, Sackett Potatoes; Tim, Todd and Chase Young, Sandyland Farms, and Karl Ritchie and Brice Stine of Walther Farms for 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; Gene Herr and Elis Cole of Herr Foods, 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 2017 Production Season

The overall 6-month average maximum and minimum temperatures during the 2017 growing season in central Michigan were similar to the 15-year average of 73^{o}F and 50^{o}F respectively (Table 1). Temperatures were slightly cooler than average in August and warmer than average in September. Extreme heat events were lower than average in 2017 (Table 2), with 14 hours over 3 days exceeding 90^{o}F during the entire summer. High nighttime temperatures (over 70^{o}F) were also lower than average with 80 hours over 18 days.

Rainfall for April through September was 15.87 inches, 0.77 inches below the 15-year average (Table 3). April and June had above average precipitation, while May and July to September had below average precipitation.

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.
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
2017	**61**	**39**	**67**	**44**	**78**	**55**	**81**	**58**	**77**	**54**	**77**	**50**	**74**	**50**
15-Year Average	58	35	68	46	78	55	81	58	80	57	74	49	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
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	19	4	106	24

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
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
2017	**4.45**	**1.98**	**6.37**	**0.92**	**1.36**	**0.7**	**15.87**
15-Year Average	2.94	3.23	2.82	2.64	2.82	2.20	16.64

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

I. 2017-2018 New Chip Processing Variety Box Bin Report

(Chris Long, Trina Zavislan, 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 2017, we evaluated and compared 32 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 8th 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: 273 lb. N/A, 99 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 20 days before harvest on October 3rd, 2017; which was 149 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 2017-2018 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 October 2, 2017, and ended June 11, 2018. Bin 7 was gassed with CIPC on November 1, 2017. We began variety evaluations on October 23, 2017, 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. Additional data is available on the program website, https://www.canr.msu.edu/potatooutreach.

Table 4. 2017-18 MPIC Demonstration Box Bin Variety Descriptions

Entry	Pedigree	2017 Scab Rating*	Characteristics
Lamoka (NY139)	NY120 X NY115	0.0	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	1.0	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	0.0	High yield, late maturity, mid-season storage, reconditions well in storage, medium to high specific gravity
AF4648-2	NY132 X Liberator	0.5	High yield potential, common scab resistant, high specific gravity, low internal defects
Hodag	Pike X Dakota Pearl	0.3	Above average yield and specific gravity, pointed tubers present in pickouts
Madison	SunRain	0.0	Very high specific gravity, early season maturity
MSR127-2	MSJ167-1 X MSG227-2	0.1	Scab resistant, high specific gravity, good chip quality from storage, above average yield potential, medium-late maturity. In the 2017 SNAC trial
MSV030-4	Beacon Chipper X MSG227-2	0.0	Above average yield and specific gravity, slight pink eyes, flattened round tuber type
MSV358-3	MSP239-1 X OP	0.0	Scab resistant with high specific gravity, has chip storage potential from 50F, in Fast Trac program
MSW075-2	MSK061-4 X Nicolet	0.0	Very low yield, good internal quality, high percentage B-sized tubers
MSW485-2	MSQ070-1 X MSR156-7	0.0	Scab resistant with moderate late-blight resistance, high specific gravity and attractive tuber shape, in Fast Track program
MSX111-3	Dakota Crisp X MSN191-2Y	0.5	High yield, high percentage US#1 tubers, slightly susceptible to internal brown spot

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
MSZ022-7	Kalkaska X Tundra	0.5	Average yield, below average specific gravity, full season maturity
MSZ052-11	Pike X MSR127-2	0.0	Sheep nose and deep apical eyes observed in 2017, below average common scab score
MSZ219-1	Saginaw Chipper X MSR127-2	0.0	Average yield, good off the farm chip score, good internal quality
MSZ219-13	Saginaw Chipper X MSR127-2	0.0	Second highest yielding variety in 2017, very large tubers size with 56% over 3.25 inches, some skinning
MSZ219-14	Saginaw Chipper X MSR127-2	0.0	Average yield, susceptible to vascular discoloration, mid-season maturity
MSZ219-46	Saginaw Chipper X MSR127-2	0.5	Below average yield, higher percentage oversized tubers, good out of the field chip color
MSZ242-13	MSR168-8Y X MSU383-A	0.0	Highest specific gravity in 2017 trials, excellent internal quality, higher percentage B sized tubers
MSZ242-9	MSR168-8Y X MSU383-A	0.0	Below average yield, vigorous vines, good fresh chip color, higher specific gravity
ND7519-1	ND3828-15 X W1353	0.0	High specific gravity, medium to high yield potential, medium vine maturity, round smooth skinned tubers
ND7799C-1	Dakota Pearl X Dakota Diamond	0.5	Average yield, very low specific gravity, susceptible to vascular discoloration
Niagara (NY152)	B38-14 X Marcy	0.0	High yield potential, medium specific gravity, moderate resistance to common scab, medium-late maturity. Fast Track program graduate
NY162	NYE106-2 X NYE48-2	1.0	High percent US #1 tubers, good internal quality, susceptible to common scab
TX09396-1W	Atlantic X Lamoka	0.0	Average yield, many oversized tubers, misshapen and knobs in pickouts
W9968-5	Fasan X Nicolet	0.0	High yield, pear shaped tubers, oval to oblong tuber type with heavy russetting

*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. 2017 MPIC Box Bin Processing Potato Variety Trial
MSU Montcalm Research Center, Montcalm County, MI

Planting: 5/8 Vine Kill: 9/13 Harvest: 10/3

GDD_{40}: 3167

	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]	VINE VIGOR[6]	VINE MATURITY[7]	COMMENTS
MSZ219-13	672	706	95	5	84	11	0	1.084	1.0	0	0	0	0	0.0	3.5	3.5	
MSX111-3	530	579	91	7	73	18	2	1.087	1.0	10	20	20	20	0.5	3.5	3.0	
NY152	519	564	92	7	90	2	1	1.094	1.0	0	10	0	0	0.0	4.0	3.0	
MSR127-2 12"	464	516	90	9	88	2	1	1.081	1.0	0	10	0	0	0.5	4.0	4.0	
MSR127-2 (Low N) 12"	452	511	88	10	84	4	2	1.087	1.0	0	20	0	0	0.0	4.0	4.0	
TX09396-1W	450	500	90	7	63	27	3	1.095	1.0	0	0	10	0	0.0	3.0	2.5	
Snowden (Low N)	448	514	87	9	85	2	4	1.094	1.0	0	0	30	0	0.0	4.0	2.5	
MSR127-2 10"	445	509	88	11	86	2	1	1.085	1.0	0	20	0	0	0.0	4.0	4.0	
Lamoka	438	499	88	12	88	0	0	1.091	1.0	0	20	0	0	0.0	4.0	2.0	
Snowden	436	512	85	13	84	1	2	1.093	1.0	0	50	0	0	0.0	4.0	2.5	
MSR127-2 (Low N) 10"	431	489	88	11	82	6	1	1.092	1.0	0	10	0	0	0.0	4.0	4.0	
Hodag	429	504	86	13	84	2	1	1.091	1.0	0	20	0	0	0.0	4.0	3.0	
AF4648-2	418	458	91	7	87	4	2	1.087	1.0	0	0	0	0	0.5	4.0	2.5	slight bruising
Manistee	408	464	88	8	82	6	4	1.087	1.0	0	10	0	0	1.0	3.5	2.0	
ND7519-1	382	449	85	13	85	0	2	1.094	1.0	20	0	0	20	0.0	3.5	2.5	
MSV030-4	379	443	85	14	83	2	1	1.096	1.0	0	0	0	0	0.0	3.0	2.5	
MSZ052-11	372	426	87	9	84	3	4	1.084	1.0	0	20	0	0	0.0	3.5	3.0	
MSV358-3	372	411	91	7	87	4	2	1.083	1.0	0	10	0	0	0.0	3.5	2.0	
Hodag (Low N)	368	454	81	19	81	0	0	1.092	1.0	0	0	0	0	0.5	3.5	3.0	
MSX540-4	352	396	89	11	89	0	0	1.094	1.0	0	0	0	0	0.0	4.0	3.5	
MSZ242-9	351	458	76	19	72	4	5	1.094	1.0	0	10	20	0	0.0	4.0	3.0	
MSZ219-1	349	370	94	6	83	11	0	1.086	1.0	0	0	0	0	0.0	4.0	3.5	
ND7799C-1	349	398	88	10	80	8	2	1.074	1.0	0	20	0	0	0.5	4.0	2.0	
W9968-5	334	384	87	7	73	14	6	1.092	1.0	10	20	10	0	0.0	3.0	3.5	
MSW485-2	328	444	74	21	73	1	5	1.092	1.0	20	0	0	20	0.0	4.0	3.0	
MSZ219-14	319	339	94	6	85	9	0	1.085	1.5	0	30	0	10	0.0	4.0	3.5	
MSZ022-7	309	352	87	10	71	16	3	1.079	1.0	0	20	0	0	0.5	3.5	4.5	
Madison	290	347	83	9	82	1	8	1.099	1.0	0	20	0	0	0.0	3.5	2.0	
NY162	278	330	84	8	72	12	8	1.078	1.0	0	0	10	0	1.0	3.5	3.0	
MSZ242-13	240	313	77	20	77	0	3	1.100	1.0	0	0	0	0	0.0	3.5	3.0	
MSZ219-46	234	246	95	5	73	22	0	1.079	1.0	0	20	0	0	0.5	4.0	3.5	
MSW075-2	125	197	64	35	64	0	1	1.078	1.0	0	0	0	0	0.0	3.5	3.0	
MEAN	**383**	**440**	**87**	**11**	**80**	**6**	**2**	**1.088**	**1.0**	**2**	**11**	**3**	**2**	**0.2**	**3.7**	**3.0**	

[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

[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

[6]**VINE VIGOR RATING**
Date: 6/15/17
Rating 1-5
1: Slow emergence
5: Early emergence (vigorous vines, some flowering)

[7]**VINE MATURITY RATING**
Date: 8/19/17
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

FIELD DATA

Planting Date	5/8/17
Vine Kill Date	9/13/17
Harvest Date	10/3/17
Days (planting to vine kill)	129
Days (planting to harvest)	149
GDD_{40} MAWN Station	Entrican
GDD_{40} (planting to vine kill)	3167
Seed Spacing	10"

***Nitrogen Treatments**
Standard Treatement: 273 Units of N over 4 application timings
Low N Treatments: 227 Units of N over 3 application timings

Results: 2017-2018 Chip Processing Box Bin Highlights

MSV030-4

This Michigan State University variety has been evaluated in the Box Bin trial for three years. At harvest, the specific gravity was 1.096, above the trial average of 1.088. The US#1 yield was 379 cwt/A, average for the trial (Table 5). MSV030-4 was chemically mature at harvest, with the sucrose rating decreasing from 0.550 to 0.548 between the two pre-harvest panels on August 16th and August 30th. 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 10/2/17 the sucrose (X10) increased to 1.587, but decreased at each sample until April. Glucose concentrations were somewhat variable, with 0.003% at the first sample, which fluctuated between October and December before remaining at 0.002 for most of January to April. Between April and the end of storage in early June both glucose and sucrose concentrations increased. The box bin had a target temperature of 54ºF, and the bin was cooled to the target by early November. It stayed between 53.6ºF and 54ºF though April, before increasing slightly to 54.6ºF just prior to bin unloading. There was no undesirable color reported, excluding 3.6 percent in February. Internal color was also good, with a high of 15.6% in early January. In all but the first and last sample, total defects were less than 20%. MSV030-4 has continued potential for commercialization in Michigan due to chip quality in long term storage, higher specific gravity, and good internal quality. This variety will be in the 2018 National SNAC variety trial.

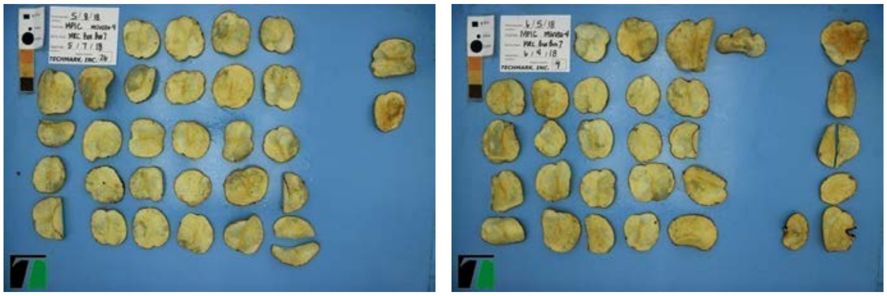


Figure 1. MSV030-4 chip samples at the last acceptable processing date, 5/7/18 (left) and at last sample date, 6/4/18 (right).

MSX540-4

This Michigan State University variety was named and released as Mackinaw in 2018. It has above average specific gravity, good chip color, and is tolerant to common scab, PVY, and late blight. In 2017 it had a slightly below average US #1 yield of 352 cwt/A compared to the trial average of 383 cwt/A. This variety does tend to have a smaller tuber size profile with more B sized tubers. It had excellent internal quality and mid-season maturity in 2017. MSX540-4 was physiologically and chemically mature at harvest as both the % glucose and sucrose decreased between the first and second pre-harvest sample. During initial bin cooling between loading and mid-October the sucrose concentration (X10) initially rose but then decreased at each sample through March. Glucose concentrations were more stable over the season, with slight fluctuations between 0.001 and 0.003 during storage, but the final glucose concentration at bin unloading was 0.002. Bin cooling for this and all other varieties is described in the MSV030-4 variety description, as all box bin are stored together. Chip quality was excellent during storage, with only one incidence of undesirable color, 2.9% in April. Internal color was also good, with thee storage samples displaying less than 10% internal color in February, April, and June. Total defects were similarly low, at or below 16%. Towards the end of storage chip quality remained good, with slightly increasing sucrose but no undesirable color and 11% total defects on June 4th. This variety will be in the 2018 National SNAC trial and will be evaluated in a bulk bin in 2018 due to its long term storage potential.

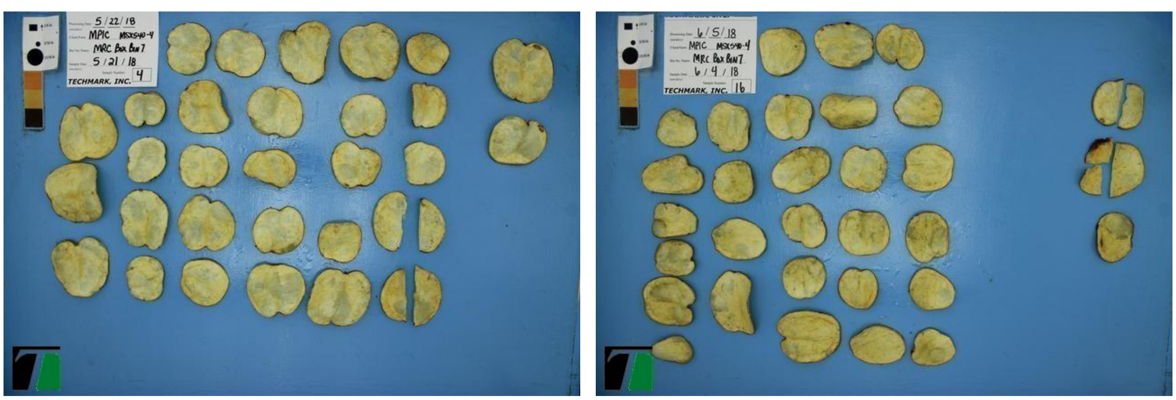


Figure 2. Mackinaw/MSX540-4 chip quality on last acceptable sample date, 5/21/18 (left) and last storage sample, 6/4/18 (right).

MSZ219-13

This Michigan State University variety had the highest US#1 and total yield in the 2017 box bin trial. The US#1 yield was 672 cwt/A and total yield was 706 cwt/A, compared to the trial average of 383 cwt/A and 440 cwt/A, respectively. MSV030-4 had slightly more oversize potatoes than average, and a specific gravity below the trial average at 1.084. It had excellent internal quality, a good off the farm chip score, and mid-season maturity in 2017. It was chemically mature at harvest, with both glucose and sucrose concentrations decreasing between the first and second pre-harvest panel. The sucrose concentration (X10) decreased from 0.514 at the first sample through mid-January. It then generally increased, most notably in April, reaching the highest concentration of 1.056 (X10) at the final sample. Glucose concentrations were more consistent, measuring between 0.001 and 0.003 in all but the last sample prior to bin unloading, when the concentration rose to 0.009. There were only three samples with undesirable color, all later in the storage season in late March, late May, and early June. There were four samples with internal color, all under 5%. At the last sample on June 4th, all chips were acceptable in terms of color and quality. This variety will be further evaluated in a box bin in 2018.

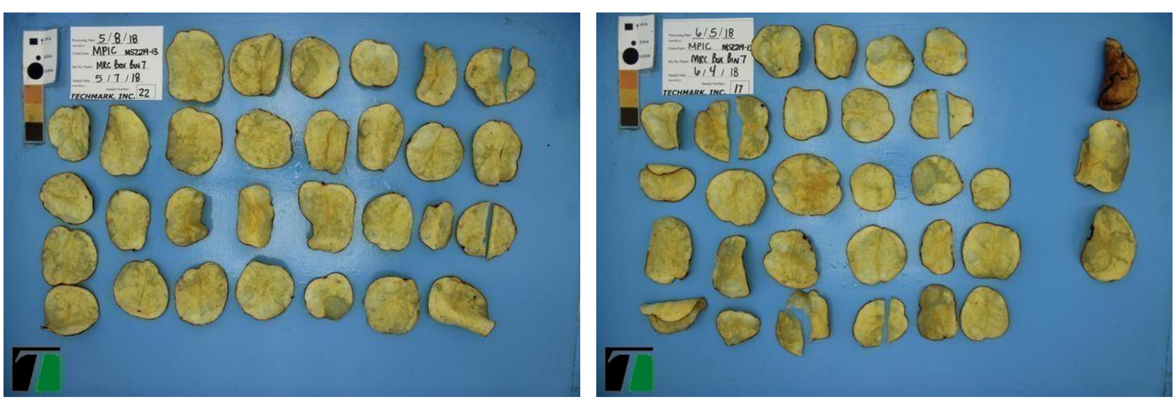


Figure 3. MSZ219-13 chip quality on last acceptable sample date, 5/7/18 (left) and last storage sample, 6/4/18 (right).

MSZ219-14

This variety is the sibling of the MSU selection MSZ219-13. In 2017 it had a lower than average yield, 319 cwt/A US#1 tubers, less than the trial average of 383 cwt/A US#1 tubers. It had a specific gravity of 1.085, slightly lower than the trial average of 1.088. Off the farm chip color was slightly darker than average, and was scored at 1.5 compared to the 1.0 average for the trial. 30% vascular discoloration and 10% brown center were observed in 2017, along with a vigorous vine and mid-season maturity. While the glucose and sucrose levels decreased between the first and second pre-harvest panel, this variety may have been slightly immature due to a sucrose concentration of 1.004 (X10) recorded on August 30th. This variety also went into storage at a temperature of 70ºF, although the temperature was cooled to 59.8ºF by the second sample date. Sucrose concentrations remained high, above 0.372 (X10) in all samples. Glucose concentrations were higher, both between 0.003 and 0.004 from October to December, and January to early February. Most samples had some internal color, with a high of 33% in early November. Total chip defects were initially high, but decreased between December and February. They rose again in March, ending with 22.2% defects in the last sample. Bruise defects, combined with darker chip color, resulted in marginal chip samples. The last sample occurred on April 9th. It will be evaluated again in the 2018 box bin trial.

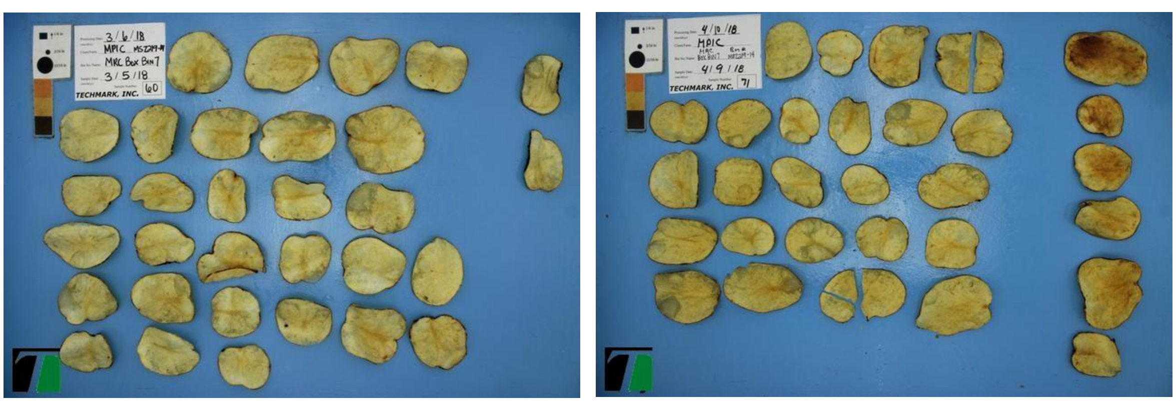


Figure 4. MSZ219-14 chip quality on last acceptable sample date, 3/5/18 (left) and last storage sample, 4/9/18 (right).

MSZ242-9

This Michigan State variety had a slightly lower than average US#1 yield of 351 cwt/A, and a smaller size profile with 19% B-sized tubers. It had a high specific gravity of 1.094, 20% internal brown spot, and 10% vascular discoloration. While glucose concentrations decreased between the first and second pre-harvest panel, sucrose concentrations increased slightly, indicating chemical immaturity. After harvest, sucrose concentrations remained high, above 0.43 (X10) until January. Levels decreased through April, but rose again in the two months before bin unloading, with the last sucrose concentration at 1.086 (X10). Glucose concentration was more stable, fluctuating between 0.001 and 0.003 from bin loading until May. It rose to 0.007 in the last sample before bin unloading. Chip color was good during storage, with only three samples containing undesirable color, all below 8%. About half of the samples had internal color, between 2.6 and 11.7%, with a general increase later in the spring. Total defects were relatively consistent, with all but the last three samples with less than 12% defects. Some bruising damage was reported in later chip samples. This variety will be further evaluated in the 2018 box bin trial.

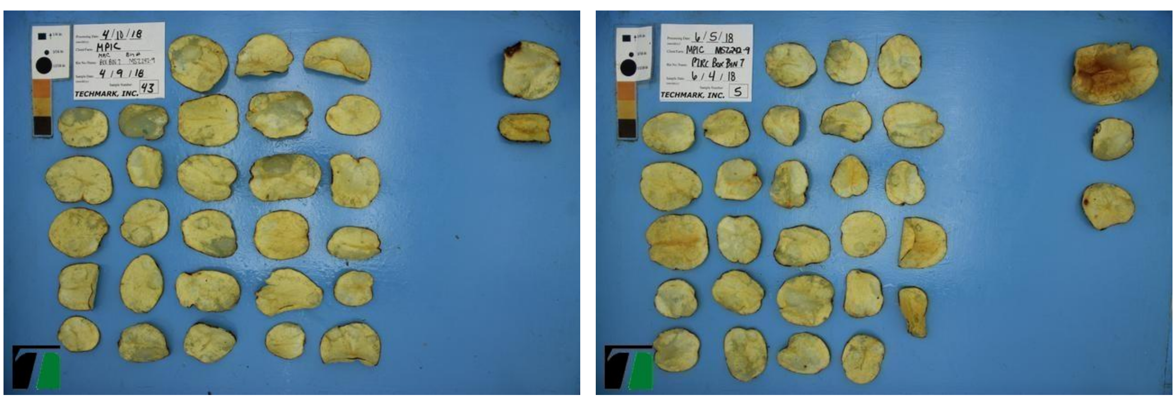


Figure 5. MSZ242-9 chip quality on last acceptable sample date, 4/9/18 (left) and last storage sample, 6/4/18 (right).

Snowden

This variety was included as a commercial standard for the 2017-2018 Box Bin Trial. The yield was above average at 436 cwt/A US#1 with an above average specific gravity of 1.093. It had 50% vascular discoloration, much higher than the trial average of 11%, but no other internal defects (Table 2). Consistent glucose and sucrose concentrations in the pre-harvest panel indicate slight chemical immaturity at harvest. On October 2, 2017, this variety was unloaded into storage and analyzed for sucrose and glucose concentrations. Sucrose concentrations followed a U-shaped trend in storage, decreasing from bin loading to a low of 0.262 (X10) in late January. Concentrations then increased until the last sample date of May 21st, with a concentration of 1.576 (X10). Glucose concentrations fluctuated between 0.001 and 0.003, until they began increasing in the last three storage samples, ending at 0.012. Chip color was good, only one sample had 5.8% undesirable color, and internal color was typically low, excluding 32% internal color in late April. Total defects were also acceptable over the storage season, generally under 20%.

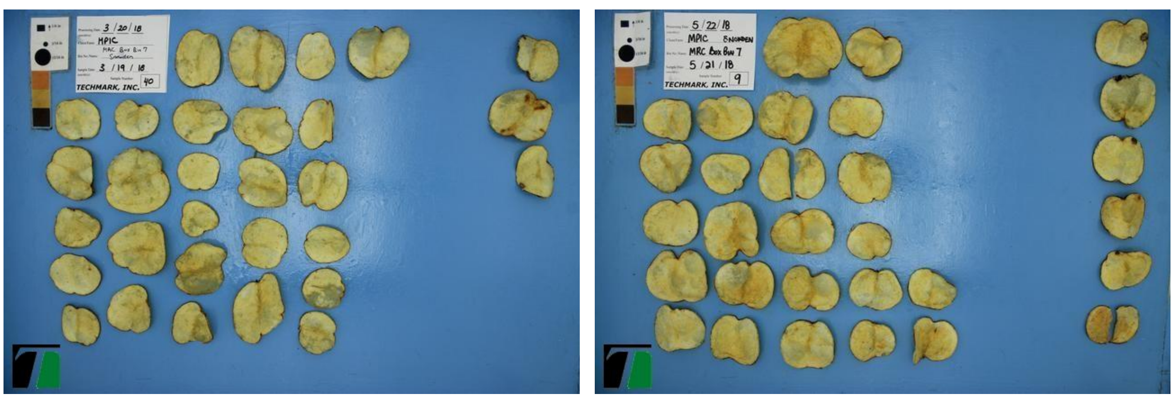


Figure 6. Snowden chip quality on last acceptable sample date, 3/19/18 (left) and last storage sample 5/21/18 (right).

II. 2017 - 2018 Bulk Bin (500 cwt. Bin) Report

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

Overview and Objectives

The goals of the MPIC Storage and Handling Committee for the 2017-2018 bulk bin storage season were: 1. To further refine optimal storage profiles for Hodag and MSX540-4 (Mackinaw), and 2. To study the effects of two different temperatures on MSR127-2, MSW485-2, and NY152 (Niagara).

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. 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. Bulk bins 2 and 3 were gassed with CIPC on November 1st, and the remaining bins were gassed on December 4th.

Bulk bin assignments are below:

1: Hodag (Sandyland Farms)

2 and 3: MSR127-2 (Sackett Potatoes)

4 and 5: Huron Chipper/MSW485-2 (Sandyland)

6: Mackinaw/MSX540-4 (Crooks Farms)

7: Box Bins

8 and 9: Niagara/NY152(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 from initial pulp temperature to suberization temperature (54ºF to 56ºF) was achieved by direct cooling, and the bun was further cooled to 50ºF at a rate of either 0.4ºF per day or 0.6ºF per day. After reaching 50ºF, later cooling occurred at a rate of 0.2ºF per day until the temperature reached 48ºF. This strategy and cooling rate is used in all bulk bins, which are cooled from field temperature to suberization temperature, to 50ºF, to the target storage temperature.

We filled Bin 1 with Hodag on October 18th. The seed was planted in Howard City, MI on May 26th and vine killed on September 12th (109 DAP, GDD_{40} 2840). This planting was harvested on October 17th, 144 days after planting. The pulp temperature for tubers at the time of bin loading was 53.4ºF, with 85 percent bruise free tubers. Bin 1 was gassed with CIPC on December 4th. It was unloaded on Jun 11th and shipped to Better Made Snack Foods, Detroit, MI.

Results

Bulk Bin 1, Hodag (GDD_{40} 2840, 48ºF)

Chip quality out of the field was acceptable with 28.7% total defects reported on the first sample date, October 23rd. 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 0.529 percent (X10) and 0.002 percent respectively with a pulp temperature of 56.6ºF. The tuber quality at bin loading was good with 85% 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 sucrose between loading and early January to 0.593 percent (X10). During this time period, glucose levels also increased, rising to a high of 0.005 percent in early January. After January, sucrose levels fluctuated through late April, reaching a low of 0.361 (X10) in late May. Once the bin reached the target temperature of 48ºF in late December, glucose decreased gradually to 0.003 percent in February, and stayed at this percentage until late May when glucose rose to 0.002 and remained at this concentration through bin unloading. During storage, internal color was excellent with a high of 7.1 percent undesirable color reported in early December. With the exception of 1.4 percent undesirable color reported in January, there was no undesirable color present during the storage season. Total defects were low overall, with three reports of no defects and the rest between 1.4 and 21.6 percent. The samples with the highest total defects were taken immediately after storage and in late March.

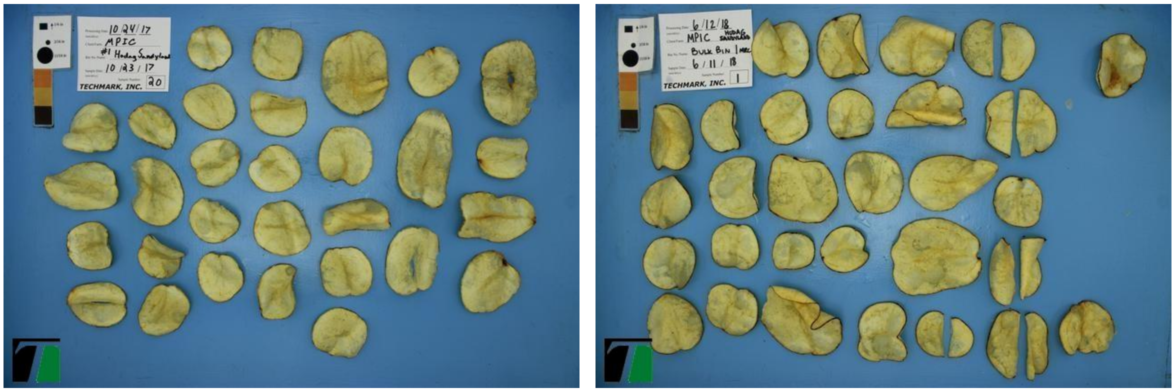


Figure 7. Bulk bin 1 out of the field chip sample on 10/23/17 and final chip sample on 6/11/18.

On June 11th the Bin was unloaded (Figure 8) and the potatoes were processed by Better Made Snack Foods in Michigan on June 12th. Upon arrival, the processor noted 4.43% brown chips and 3.55% internal defects for a total of 7.98% defects. This load was accepted as total defects were below 17%. Specific gravity was 1.086. The Agtron machine was not working during processing so chip color was evaluated visually using the SFA scale, and received a score of 1.5. The Potato Outreach Program was able to visit Better Made Snack Food and observe the chipping process (Figure 9). Samples from this load were bagged and taken to Michigan State University for further visual evaluation. Using unbroken chips, POP staff sorted the chips into acceptable, sugar defects, internal defects, and external defects. A breakdown of 86% acceptable, 4% sugar defects, 4% external defects, and 6% internal defects was reported (Figure 10). Hodag continues to be a promising variety with commercialization potential in Michigan. It will be further evaluated in the 2018 to 2019 storage season in a bulk bin.

Figure 8. Hodag potatoes at bin unloading on 6/11/18.

Figure 9. Hodag potatoes at Better Made Snack Foods before and after chipping on 6/12/18

Figure 10. Hodag potatoes visually sorted by defect type.

Table 6. 2017-2018 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'	4.90	22.00	2.33	0.67	0.00	88.0	10.7	1.3
8'	5.25	15.00	7.67	2.33	0.00	54.0	60.0	6.0
3'	-	8.67	9.33	6.00	1.00	34.7	54.7	10.7
OVERALL AVERAGES	**5.08**					**58.9**	**41.8**	**6.0**

[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	10/18/17	Pulp Temp. (at Filling)	53.4ºF		
Unloaded	6/11/18	Target Storage Temp.	48.0ºF	End Temp.	50.8ºF

MSR127-2 Storage Trial (Bins 2 and 3)

This Michigan State University variety had commercialization potential in Michigan due to high yield potential, a higher percentage of US #1 tubers, common scab tolerance, above average specific gravity, and good chip color. These two bulk bins were filled with potatoes grown by Sackett Potatoes in Mecosta, MI. The potatoes in both bins were planted on May 17th and vines were killed on September 21st (127 DAP, GDD_{40} 3266). Harvest occurred on October 9th, 146 days after planting. At harvest the pulp temperature was 55ºF for Bin 2 tubers and 57ºF for Bin 3 tubers. The tubers incurred mechanical damage prior to storage with 33% and 42% bruise free tubers, respectively. The potatoes were physiologically and chemically mature at harvest, with consistent glucose and decreasing sucrose concentrations between the two pre-harvest panel samples. The bins were loaded on October 9th and treated with CIPC on November 1st. These bins were designed to study chip quality and potato storability under two different shorter-term storage protocols. Tuber breakdown necessitated earlier shipping, so temperature effect on chip quality was not fully studied with this variety.

Results

Bulk Bin 2, MSR127-2 (GDD_{40} 3266, 55ºF)

The potatoes in this bulk bin were held between 55ºF and 56ºF while fresh air was forced through the pile through December. Chip quality remained marginal during early storage as sucrose concentrations remained above 0.500 for all but two sample dates and as glucose concentration (X10) rose from 0.003 to 0.009 in November before gradually decreasing. Internal color and total defects were consistently high, with the lowest total defect level of 20% recorded in February just before bin unloading. During this time the tubers began physiologically breaking down, causing free moisture in the plenum to become unmanageable. The chip quality and high stem end defects made the potatoes unacceptable for dehydration processing, and the tubers were unloaded and spread. Therefore, no processor data is available for Bin 2.

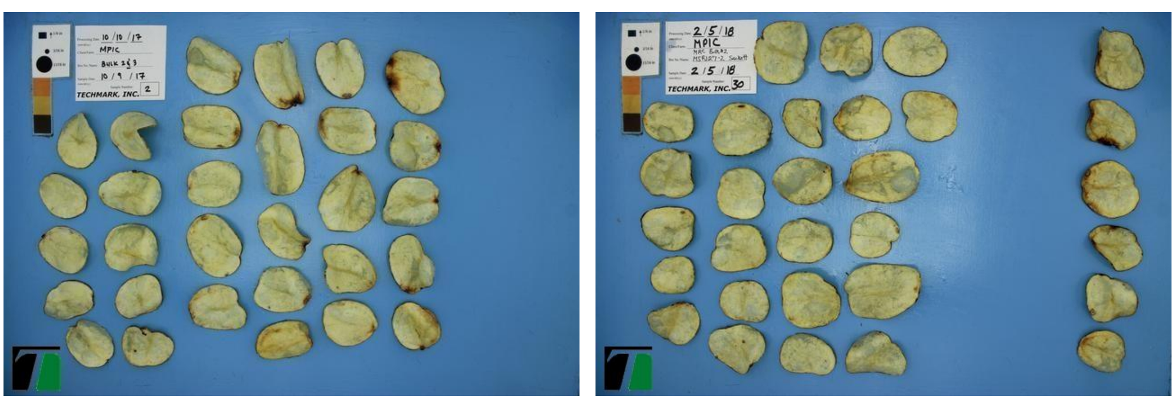


Figure 10. Bulk bin 2 out of the field chip sample on 10/9/17 and last chip sample on 2/5/18.

Bulk Bin 3, MSR127-2 (GDD$_{40}$ 3266, 55ºF)

This bulk bin was initially cooled and held between 55^{o}F and 56^{o}F while fresh air was forced through the pile through December. Chip color and defects remained marginal, so further cooling was not attempted. The sucrose concentration gradually decrased during storage, reaching a low of 0.473 (X10) in late January, but then rose to 1.051 in March, shortly before bin unloading. Glucose concentrations initially increased in storage to a high of 0.010 in late November, but gradually decreased until the last sample date in mach, when it rose to 0.011. These higher levels of glucose and sucrose caused correspondingly marginal chip quality, with moderate to severe stem end defect observed at sampling. The severity of stem end defect prevented processing, and the bin was unloaded with the tubers spread in late March. This bulk bin study concluded the research on MSR127-2, and the variety is no longer evaluated by Michigan State University.

Figure 11. Bulk bin 3 out of the field chip sample on 10/9/17 and last chip sample on 3/19/18.

Figure 12. Unloading bulk bin 2 on 2/16/18 (left) and bulk bin 3 on 3/22/18 (right).

Table 7. 2017-2018 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	11.66	13.50	7.50	4.00	0.00	54.0	42.0	4.0
8' Bin 2*								
3' Bin 2	12.30	9.33	9.00	2.33	4.33	37.3	32.0	30.7
OVERALL AVERAGES	**11.98**					**45.7**	**37.0**	**17.4**
14’ Bin 3	11.05	8.50	9.50	5.50	1.50	22.7	76.0	1.3
8’ Bin 3	12.94	8.50	11.00	4.00	1.50	22.7	74.7	2.7
3’ Bin 3	16.51	2.33	8.00	9.67	5.33	9.3	62.7	28.0
OVERALL AVERAGES	**13.50**					**18.2**	**71.1**	**10.7**

[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	10/9/17 (both)	Pulp Temp. (at Filling)	55.0ºF (2) 57.0ºF (3)		
Unloaded	2/16/18 (2) 3/19/18 (3)	Target Storage Temp.	N/A	End Temp.	56.4ºF (2) 55.0ºF (3)

*Samples discarded due to rot

MSW485-2/ Huron Chipper Storage Trial (Bins 4 and 5)

This Michigan State University variety was named and released as Huron Chipper. In 2017 it had many promising characteristics, including high yield across national trials, above average specific gravity, and resistance to Late Blight and common scab. These two bulk bins were filled using potatoes grown at Sandyland Farms, Howard City, MI. The potatoes were planted on May 26th, and vines were killed on September 12th (110 DAP, 2840 GDD). Harvest occurred on October 17th, 145 days after planting. At harvest the pulp temperature was 52.3ºF for Bin 4 and 48.0ºF for Bin 5. The tubers were in good condition at harvest, with 95% and 73% bruise free, respectively. At harvest, the tubers were chemically immature, with glucose and sucrose concentrations increasing between pre-harvest panel samples. The bins were loaded on October 18th and treated with CIPC on December 14th. These bins were designed to establish storage protocols and target temperatures based on sucrose and glucose responses to lower temperatures.

Results

Bulk Bin 4, MSW485-2/Huron Chipper (GDD_{40} 2840, 50ºF)

The temperature in Bulk Bin 4 was gradually cooled from 56.8ºF to 54ºF in December with fresh air forced through the pile. Temperature strategy is this. The bin reached a final temperature of 49.8ºF on May 14th. Sucrose concentration decreased in storage from the relatively high concentrations during the pre-harvest panel. The first sample on October 23rd had a sucrose concentration of 0.460 (X10), which decreased further for each sample until February. Between February and shipping in May, sucrose increased to reach a high of 1.105 (X10) at the last sample date. Glucose concentrations follow a similar pattern, initially decreasing to a low of 0.002 in February, and gradually increasing to 0.011 in the sample prior to bin unloading. There was no undesirable chip color observed until the very end of storage. Internal color was also good until it increased sharply between March and unloading, ending with 61.5% internal color. Total defects were initially high for the first three sample dates, but were below 20% between January and April.

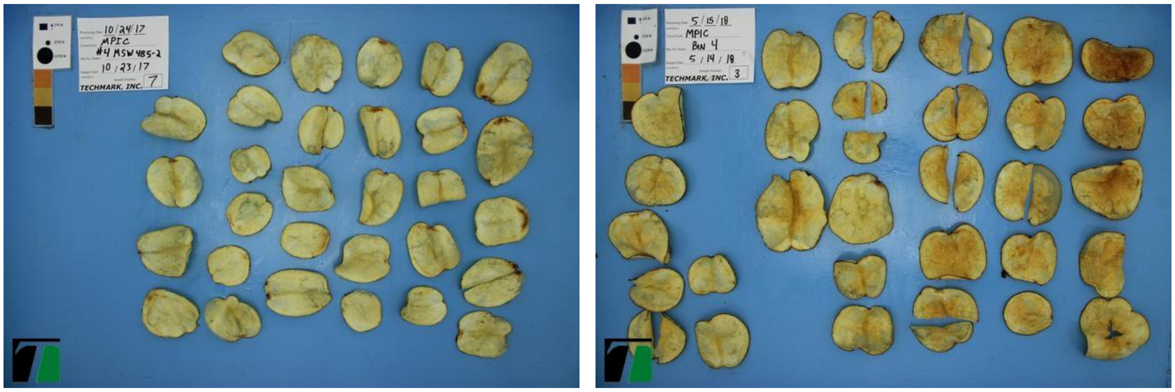


Figure 13. Bulk bin 4 first chip sample on 10/23/17, and last chip sample on 5/14/18.

On May 14, the bin was unloaded and the potatoes were shipped to Herr Foods, Inc., Pennsylvania for processing on May 15th. The specific gravity at processing was 1.089, and Frito-Lay solids were 18.36. This bin processed marginally, with many sugar defects noted. POP staff used unbroken chips from this load to separate defects by type: sugar, internal, and external (Figure 14). 71% of chips were acceptable, 8% had browning due to high sugars, 7% external defects, and 14% internal defects, of which 7% were stem-end defect.

Figure 14. Bulk Bin 4 chips visually sorted by defect type.

Bulk Bin 5, MSW485-2/ Huron Chipper (GDD_{40} 2840, 48ºF)

Bulk bin 5 had a slightly lower initial pulp temperature of 48ºF compared to bin 4, and also had a higher percentage of bruised tubers. Both glucose and sucrose concentrations formed a U-shaped curve over the storage season, with higher initial values decreasing to the lowest point in late January and early February, followed by a gradual increase until bin unloading. The initial sucrose concentration of 0.540 (X10) decreased to 0.273 (X10) in late January, and then gradually increased at each sample date, ending at 1.060 (X10) at bin unloading. The initial glucose concentration of 0.003 rose to 0.006 in late November, but reached a low of 0.001 in early February. Concentrations then increased at each sample date until May 14th with a concentration of 0.027. There were only two samples with undesirable color, 1.5% in late October and 6.3% at bin unloading. Total defects and internal color were generally acceptable, and were excellent between January and April, not exceeding 15%. Both values rose from mid-April to bin unloading, ending with 53.5% internal color and 64.5% total defects. Bulk bin 5 was processed at the same time as Bin 4 by Herr foods, and processed similarly. POP staff used unbroken chips from this load to separate defects by type: sugar, internal, and external (Figure 15). 70% of chips were acceptable, 14% had browning due to high sugars, 4% external defects, and 11% internal defects, of which 4% were stem-end defect. Based on glucose and sucrose concentrations in conjunction with chip quality, these bins may have processed more satisfactorily in April with much lower sugar defects. Both chip images from the March 19th sample display good chip color and quality, indicating that Huron Chipper may have potential for intermediate, not long term storage.

Figure 15. Bulk Bin 4 chips visually sorted by defect type.

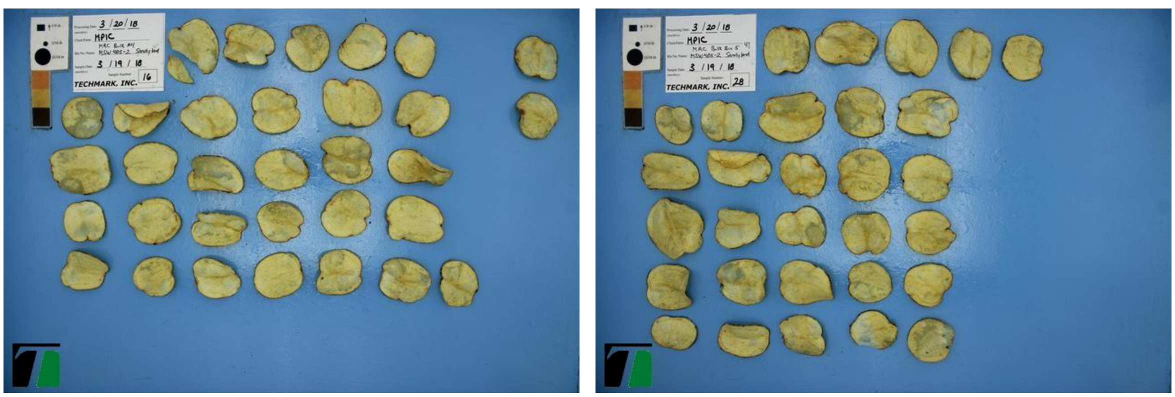


Figure 16. MSW485-2/Huron Chipper bin 4 (left) and 5 (right) chip quality on 3/19/18.

Table 8. 2017-2018 PRESSURE BRUISE DATA Bulk Bin #4 and #5 MSW485-2/Huron Chipper (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 4	5.01	20.33	4.67	0.00	0.00	81.6	18.7	0.0
8' Bin 4	5.57	18.33	6.33	0.33	0.00	73.3	26.7	0.0
3' Bin 4	6.23	11.33	7.67	4.00	2.00	45.3	46.7	8.0
OVERALL AVERAGES	**5.60**					**66.7**	**30.7**	**2.7**
14’ Bin 5	3.90	19.33	5.00	0.67	0.00	77.3	22.7	0.0
8’ Bin 5	8.29	12.33	9.33	2.33	0.00	49.3	50.7	0.0
3’ Bin 5	6.31	15.00	8.67	1.33	0.00	60.0	36.0	4.0
OVERALL AVERAGES	**6.16**					**62.2**	**36.4**	**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	10/18/17	Pulp Temp. (at Filling)	52.3ºF (4) 48.0ºF (5)		
Unloaded	5/14/18 (4) 5/14/18 (5)	Target Storage Temp.	44.0ºF (4) 46.0ºF (5)	End Temp.	49.8ºF (4) 47.8ºF (5)

MSX540-4/Mackinaw Storage Trial (Bin 6)

MSX540-4 was recently named Mackinaw Chipper and commercially released by Michigan State University. It has several beneficial characteristics, including above average yield in Michigan trials, above average specific gravity, good raw internal quality, and resistance or tolerance to common scab, PVY, and late blight. It also has a low incidence of stem end defect. The purpose of this bin study was to refine the storage profile, and lower the bin temperature while still achieving acceptable glucose and sucrose concentrations, thereby maintaining chip quality.

Tubers for bin 6 were harvested from Crooks Farms, Stanton, MI on October 12th with a pulp temperature of 62.7ºF. Only 39% of tubers were bruise free. Bin 6 was gassed with CIPC on December 4th, and was unloaded on May 30th and shipped to Utz Quality Foods, Pennsylvania for processing on May 31st.

Results

Bulk Bin 6, MSX540-4/Mackinaw (GDD_{40} 2953, 46ºF)

This variety was planted on May 24th and vines were killed on September 15th (114 DAP, GDD_{40} 2953). Potatoes were harvested on October 21st, 150 days after planting. Chip quality out of the field was good with 13.4% total defects reported on the first sample date, October 23rd. The bin was cooled to 48ºF at a rate of 0.2ºF per day until December, after which it was further cooled to the target temperature of 46ºF. MSX540-4 was slightly 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 sucrose between loading and early January when sucrose remained above 1.000 (X10). During this same time period, glucose levels fluctuated between 0.002 and 0.004, but did not increase comparably to sucrose. Despite high sucrose levels, percent undesirable color and internal color were very low, with internal color only increasing in late April. While total defects were initially high through December, reaching 46.7%, chip quality was generally good with 25% or fewer total defects between February and early May.

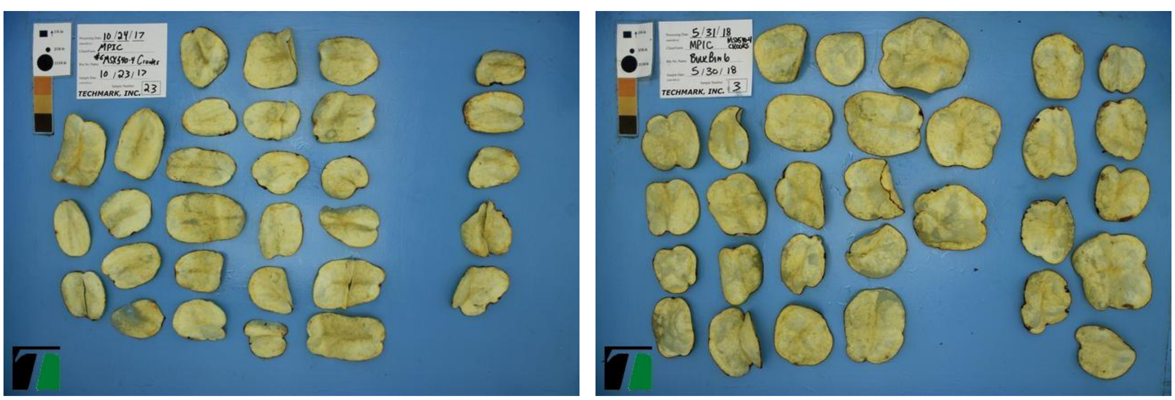


Figure 17. Bulk bin 6 initial chip sample on 10/23/17 and final chip sample on 5/30/18.

While the initial storage plan called for a June shipping date, the bin was unloaded on May 30th, and potatoes were sent to Utz Quality Foods, Pennsylvania (Figure 18). The specific gravity was 1.089 at processing with Frito Lay solids at 17.92. At processing, Utz noted 2% internal defects and 8% external defects (Figure 19). Stem end defects were noted by both Techmark Inc. during storage sampling and by Utz during processing. This was likely due to free sugars and tuber physiological age. This variety continues to demonstrate good chip quality in Michigan and will be further evaluated in bulk bins in the 2018-2019 storage season.

Figure 18. Bulk bin 6 unloading on 5/30/18.

Figure 19. Chip samples after processing at Utz Quality Foods, 5/31/18.

Table 6. 2017-2018 PRESSURE BRUISE DATA
Bulk Bin #6 MSX540-4/Mackinaw (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'	5.24	12.33	10.67	1.67	0.33	49.3	42.7	8.0
8'	5.63	11.67	7.00	6.00	0.33	46.7	38.7	14.7
3'	5.61	12.67	6.33	4.00	2.00	50.7	40.0	9.3
OVERALL AVERAGES	**5.49**					**48.9**	**40.4**	**10.7**

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	10/21/17	Pulp Temp. (at Filling)	62.7ºF		
Unloaded	5/30/18	Target Storage Temp.	46.0ºF	End Temp.	60.0ºF

NY152 Storage Trial (Bins 8 and 9)

NY152, a Cornell University variety, was recently named and released as Niagara. This variety has above average yield, average specific gravity, lower stem end defect incidence, some common scab tolerance, and a smaller, uniform round tuber size profile. This variety was planted on May 24th and vines were killed on September 15th (114 DAP, GDD_{40} 2953). Potatoes were harvested on October 21st, 150 days after planting in Stanton, MI. At bin loading, bin 8 had a pulp temperature of 61.8ºF and bin 9 had a pulp temperature of 59.4ºF. Both bins were gassed with CIPC on December 4th. The potatoes displayed characteristics of physiological and chemical maturity at harvest and had a specific gravity of 1.069 on August 30th, the second pre-harvest panel sample. Sucrose and glucose concentrations decreased between the first and second pre-harvest sample. Both bins were unloaded in early June and processed by Utz Quality Foods, Pennsylvania. These bulk bins were used to further refine acceptable temperatures NY152/Niagara tolerates in storage. Bin 8 had a target temperature of 48 F while the temperature in Bin 9 was decreased to 46 F for most of January to April.

Results

Bulk Bin 8, NY152/ Niagara, (GDD_{40} 2953, 48ºF)

Bulk bin 8 had high initial sucrose, with levels fluctuating between 0.815 and 1.086 (X10) between late October and January. After this time, concentrations decreased to a low of 0.447 (X10) in late May, followed by a slight increase shortly before bin unloading. Glucose levels were more consistent, with concentrations between 0.001 and 0.004 for the duration of storage. Undesirable color was very low with a high of 4.1% in late March. All other samples had no undesirable color. Internal color was also low, with eight samples at 0% undesirable color and the remaining values below 12%. Similarly, total defects were typically low, with most samples having less than 20% total defects. The storage season began with a temperature of 61.4ºF that was dropped to 50.2 by mid-November. After this, the temperature was lowered more gradually to the target temperature of 48.0ºF, and slightly raised a month prior to bin unloading.

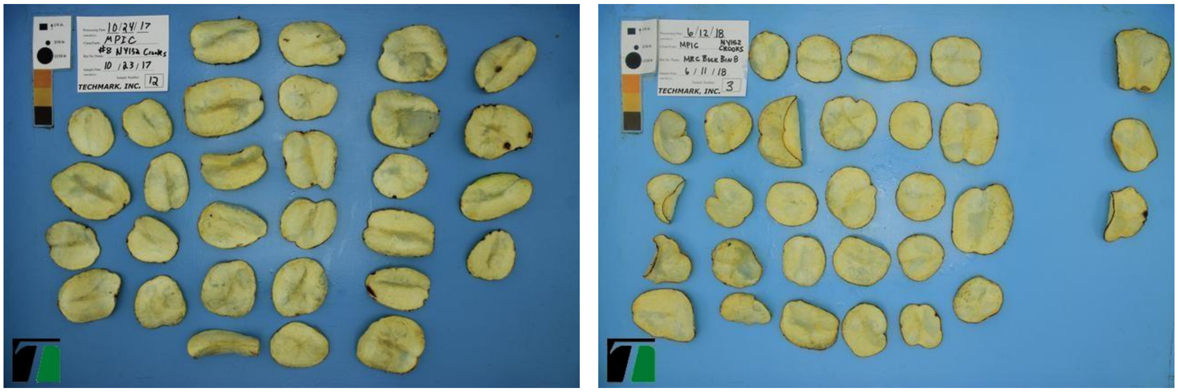


Figure 20. Bulk bin 8 out of the field chip sample on 10/23/17, and last chip sample on 6/18/18.

Bulk bin 8 was unloaded and processed by Utz Quality Foods, Pennsylvania, on June 11th (Figure 21). The specific gravity at processing was 1.090 and Frito Lay solids were 17.22. Bulk bin 8 had 1% internal defects and 7% external defects. Niagara is susceptible to common scab, and a close-up image of scab lesions was taken at Utz (Figure 22).

Figure 21. Unloading bins 8 and 9 on 6/11/18, prior to shipping to Utz Quality Foods.

Figure 22. Chip internal quality and scab lesions in bin 8.

Bulk Bin #9, NY152/ Niagara, (GDD$_{40}$ 2953, 46ºF)

Bulk bin 9 had a lower target temperature than Bin 8, and was stored at 46ºF from January through late April. Storage temperature was increased to 47.4ºF prior to bin unloading. Compared to Bin 8, Bin 9 had lower initial sucrose levels, which remained lower for the first four storage samples. However, the sucrose concentrations then failed to decrease as quickly or by as much as they did in Bin 8, staying approximately 0.100 (X10) higher than the levels in Bin 8 at comparable dates. However, both bins had approximately the same sucrose concentration at bin unloading, 0.596 (X10) in Bin 9 and 0.576 (X10) in Bin 8. Glucose concentrations followed a similar trend to Bin 8, fluctuating between 0.001 and 0.003 during storage. Percent undesirable color was similar in both bins, but Bin 9 had a slightly higher percentage of undesirable color compared to Bin 8. This in turn led to similar, but higher levels of total defects in Bin 9, reaching a high of 26.6% total defects in late April.

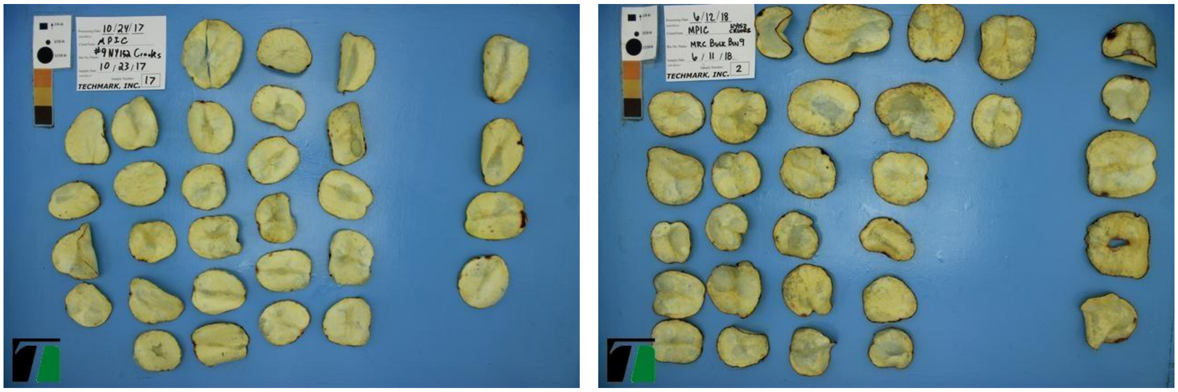


Figure 22. Bulk bin 9 out of the field chip sample on 10/23/17, and last chip sample on 6/11/18.

Bulk bin 9 was unloaded and processed by Utz Quality Foods, Pennsylvania, on June 11th (Figure 21). The specific gravity at processing was 1.091 and Frito Lay solids were 17.08. Internal quality was good, with 2% internal defects and 4% external defects. Some chip blistering was observed, and tubers had common scab (Figures 23 and 24).

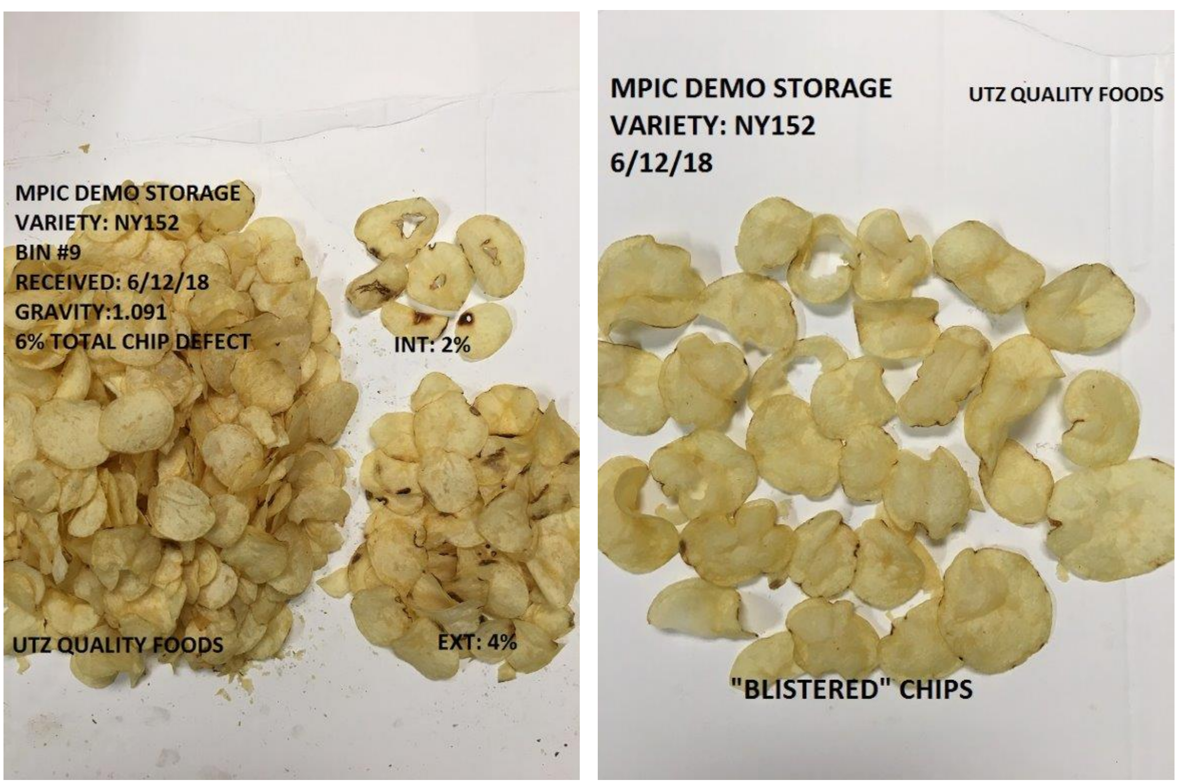


Figure 23. Internal chip quality and chip blistering observed in bin 9.

Figure 24. Close up image of scab lesions in bin 9.

Table 9. 2017-2018 PRESSURE BRUISE DATA
Bulk Bin #8 and #9 NY152/ Niagara (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

Potato Response to Phosphorus Applications

Kurt Steinke and Andrew Chomas, Michigan State University

See soil.msu.edu for more information

Location: Montcalm Research Farm	**Tillage**: Conv., 34-in. row
Planting Date: May 7, 2018	**Trt's**: See below
Soil Type: Loamy sand; 1.3 OM; 6.0 pH; 157 ppm P; 96 ppm K; CEC: 4.6	**Emerge:** June 4 **Hill:** June 20
Variety: Snowden	**Replicated**: 4 replications

P Trt. (Total lb. P_2O_5/A)	Pet. P 30 DAE %	Pet. P 45 DAE %	Tuber Count B's (count/plot)	Yield A's (cwt/A)	Total Yield (cwt/A)	Sp. Gravity
0 – Check	0.50	0.43	31	291	328	1.076
40	0.47	0.42	29	359	392	1.079
80	0.48	0.44	25	406	435	1.081
120	0.53	0.40	21	343	372	1.078
160	0.63	0.45	17	360	390	1.077
200	0.63	0.45	22	368	391	1.079
$LSD_{(0.10)}$[a]	**0.05**	**NS**	**8.3**	**NS**	**NS**	**NS**

[a] LSD, least significant difference between means within a column at ($\alpha = 0.10$).

Summary: Trial quality was good. All treatments received 226 N and 300 K_2O with all P_2O_5 applications banded 2x2 at planting. Potassium was applied as 75 units in-furrow and 225 units pre-plant incorporated. Nitrogen applications were split into 3 application timings including emergence, hilling, and post-hilling. In the current study, 80 lbs P_2O_5/A resulted in the greatest total yield and A size yield with no benefit at rates greater than 80 lbs P_2O_5/A. Regression analyses indicated optimal P_2O_5 application rates of 45-60 lbs./A for both total and A size yields. Phosphorus application rates less than 80 lbs/A significantly increased the number of B size tubers compared to greater P_2O_5 application rates but no significant effects on the number of A size tubers or total tubers set were observed. Greater rates of N application at plant due to increased rates of P_2O_5 increased overall calcium and manganese petiole concentrations at 30 DAE but were not impacted thereafter. Increased rates of P_2O_5 at-planting did significantly increase petiole P at 30 DAE but results were not significantly different at 45 DAE and later. Please visit soil.msu.edu for further details and other field crop research results.

Starter Potassium Effects on Potato Yield and Specific Gravity

Kurt Steinke and Andrew Chomas, Michigan State University

See soil.msu.edu for more information

Location: Montcalm Research Farm	**Tillage**: Conv., 34-in. row
Planting Date: May 7, 2018	**Trt's**: See below
Soil Type: Loamy sand; 1.3 OM; 6.0 pH; 157 ppm P; 96 ppm K; CEC: 4.6	**Emerge:** June 4 **Hill:** June 20
Variety: Snowden	**Replicated**: 4 replications

K Rate (lb. K2O/A)	Timing	Pet. K 30 DAE %	Pet. K 45 DAE %	Yield A's (cwt/A)	Total Yield (cwt/A)	Sp. Gravity
0 – Check	----	5.7	5.6	306	332	1.086
225 75	PPI In-furrow	7.1	7.9	354	380	1.081
150 150	PPI In-furrow	7.6	7.5	352	379	1.080
300	PPI	6.9	6.3	359	383	1.082
105 75 120	PPI In-furrow Hill	7.0	7.3	356	381	1.083
165 75 60	PPI In-furrow Hill	7.1	7.0	312	349	1.083
187 113	PPI In-furrow	8.0	6.4	325	378	1.085
$LSD_{(0.10)}$[a]	**----**	**1.0**	**0.9**	**NS**	**NS**	**0.003**

[a] LSD, least significant difference between means within a column at ($\alpha = 0.10$).

Summary: As potato production further expands into leased, marginally productive soils, questions pertaining to the rate and effectiveness of potassium on both yield and quality continue to arise. Trial quality for this study was good. All treatments received 226 N, 120 P_2O_5, and 300 K_2O. Nitrogen applications were split into 3 application timings including emergence, hilling, and post-hilling. In the current study, at least 75 units K_2O in-furrow appeared to stabilize petiole K at both 30 and 45 DAE. Hilling applications of K_2O did not appear to benefit overall total yield or A size yield. Cation nutrient levels decreased with greater rates of K_2O applied in-furrow indicating some degree of cation antagonism. No effects of K_2O were observed on overall tuber set. Please visit soil.msu.edu for further details and other field crop research results.