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In Cooperation With
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MICHIGAN POTATOES
MICHIGAN POTATO INDUSTRY COMMISSION

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December 12, 2022

To all Michigan Potato Growers and Shippers,

The Michigan Potato Industry Commission continues to provide over $179,000 in direct funding on an annual basis for potato research. This research is the one of the core components that continue to move the Michigan potato industry forward. Expanding research has provided increased insights into varieties, disease, soil fertility, and storage management. Research outcomes continue to provide a competitive advantage for the industry in Michigan and to provide Michigan with a highly respected reputation among the national industry professionals.

The following research report was compiled with the help of the Michigan State University AgBioResearch and Michigan State University Extension. On behalf of all parties, we are proud to present you with the results of the 2022 potato research projects.

We hope that each of you see value in the investment made in these projects and can apply some of the results directly to strengthen your own operation.

We would like to thank our many suppliers, researchers, and industry partners who are involved in making this year's research season a success even on the heels of a global pandemic. As the industry faces new challenges and strives to improve upon best practices, we are inspired by the level of cooperation within the industry and look forward to future success together.

Sincerely,

Kelly Turner

Dr. Kelly Turner, Ed. D, CAE
Executive Director

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2022 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2022 Potato Research Report contains reports of the many potato research projects conducted by Michigan State University (MSU) potato researchers at several locations. The 2022 report is the 54th 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 principal 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 VanAtta, MSU for organizing and compiling this final draft.

WEATHER

The overall 6-month average maximum and minimum temperatures during the 2022 growing season were consistent with the 15-year averages at 72ºF and 50ºF respectively (Table 1). May and September had slightly cooler temperatures than the maximum average. All other months were consistent with the 15-year averages. Daytime extreme heat events were average in 2022 with 11 hours over two days in which temperatures exceeded 90ºF during the summer. Extreme high nighttime temperatures were below average in 2022, with 123 hours of nighttime temperatures above 70ºF over 26 days, compared to the seven-year average of 138 hours over 30 days (Table 3).

Rainfall for April through September was 19.82 inches, which was 1.34 inches above the 15-year average (Table 2). A total of 7.5 inches of irrigation water over 12 application timings was applied to MRC 1 between late May and late August. In general, May, June, and September were drier than average while April, July, and August had more precipitation than average.

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

Year	April		May		June		July		August		September		Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
2008	60.6	33	66.6	40	77	56	80.1	58	79.9	54.4	72.9	50.1	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	73	49
2015	58	33	71	48	76	54	80	56	77	57	77	54	72	49
2016	53	32	70	45	78	53	82	60	85	60	78	54	73	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
2019	55	35	65	45	75	54	84	69	80	55	73	54	72	52
2020	56	29	76	35	77	54	81	68	78	60	70	48	73	49
2021	58	35	69	41	80	58	81	58	85	59	76	50	75	50
2022	**51**	**33**	**71**	**45**	**79**	**55**	**81**	**58**	**79**	**58**	**71**	**52**	**72**	**50**
15-Year Average	56	33	70	45	78	55	82	60	80	57	74	50	73	50

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

Year	April	May	June	July	August	September	Total
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	21.5
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	0.70	15.78
2018	2.04	5.51	3.64	1.19	7.73	2.65	22.76
2019	2.64	5.46	2.9	2.04	3.31	5.72	22.07
2020	3.49	4.75	1.40	4.07	2.21	3.12	19.04
2021	1.71	2.18	5.58	4.79	3.52	3.71	21.49
2022	**3.44**	**2.67**	**1.59**	**3.37**	**6.56**	**2.19**	**19.82**
15-Year Average	3.26	3.33	3.00	2.61	3.64	2.65	18.48

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

Year	Temperatures > 90°F Hours	Temperatures > 90°F Days	Night (10pm-8am) Temperatures > 70°F Hours	Night (10pm-8am) Temperatures > 70°F Days
2016	26	7	248	50
2017	14	3	80	18
2018	11	4	123	31
2019	0	0	104	20
2020	12	3	123	30
2021	0	0	168	35
2022	**11**	**2**	**123**	**26**
Average	11	3	138	30

GROWING DEGREE DAYS

Table 4 summarizes the cumulative growing degree days (GDD) for 2022 while providing historical data from 2010-2021. 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 at the end of September in 2022 was 3892 (Table 4), which is 51 GDD higher than the 13-year average of 3841.

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

	Cumulative Monthly Totals				
Year	May	June	July	August	September
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
2019	457	1189	2179	3024	3731
2020	488	1298	2331	3241	3809
2021	494	1362	2276	3269	3956
2022	**625**	**1434**	**2345**	**3240**	**3892**
Average	567	1340	2292	3188	3841

*2008-2022 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 2022 was Montcalm Research Center property in the field referred to as 'MRC1.' This acreage was planted to rye in the spring of 2021 with crop residue disked into the soil in fall and sprayed off in the spring of 2022. In the spring of 2022, the recommended rate of potash was broadcast applied following deep-chisel plowing. The ground was vertical tilled and direct planted to potatoes. The area was not fumigated with Vapam prior to potato planting, but Admire Pro® was applied in-furrow at planting.

The soil test analysis for the general crop area (taken in November 2021) was as follows:

	lbs/A			
pH	P	K	Ca	Mg
6.3	300 (150 ppm)	226 (113 ppm)	1164 (582 ppm)	190 (95 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	40 gpa 40 gpa	72-0-0 14-49-0
At-cultivation	28-0-0 10-34-0	70 gpa 70 gpa	72-0-0 14-49-0
At-hilling	46-0-0	100 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 Linex4l/Dual II at 1.25 qts/A was made inearly June. Admire Pro® was applied in-furrow at planting at a rate of 8.7 fl oz/A.

Post emergence, Tricor/Dual II was applied in early July at 1.25 qts/A.

Manzate was applied at 1 qt/A three times in July, and six times at 2 qt/A six times between late July and early September. Oranil 6l was applied in late July at 1 pt/A.

Potato vines were desiccated with Reglone in late August and early September at a rate of 32 oz/A.

Funding: Federal Grant, MPIC and Potatoes USA/SNAC

2022 On-Farm Potato Variety Trials

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INTRODUCTION

Our main objectives for on-farm potato variety trials are to: 1) identify promising lines for further testing and evaluation, 2) conduct larger scale commercial agronomic and processing trials through multi-acre block plantings, and 3) use trial data to encourage the commercialization of new varieties in the state of Michigan. We share our results with growers, breeders, and processors across the country to aid in the development of new varieties. In 2022, we conducted 35 on-farm potato variety trials with 13 growers in 11 counties.

Processing trial cooperators were: 4-L Farms (Kalamazoo), Black Gold Farms (St. Joseph), Hampton Potato Growers (Bay), Lennard Ag. Co. (Branch, St. Joseph), Main Farms (Montcalm), Sandyland Farms (Montcalm), Verbrigghe Farms (Delta), 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 (Kalamazoo), Elmaple Farms (Kalkaska), Horkey Bros. (Monroe), Jenkins Farms (Kalkaska), Kitchen Farms, Inc. (Antrim), Lennard Ag. Co. (St. Joseph), Styma Potato Farms (Presque Isle), Verbrigghe Farms (Delta), and Walther Farms, Inc. (St. Joseph, Tuscola)

PROCEDURE

A. Processing Variety Trials

We evaluated 80 chip processing varieties in 2022. To evaluate selected processing lines, we used the following check varieties: Atlantic, Lamoka, and Snowden. For all trials, we used 10” in-row seed spacing and 34” rows (Table 2).

Most of our processing trials were strip trials. These trials consisted of a single 75’ 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 Sandyland Farms, Thorlund Bros., Lennard Ag. Co., and Walther Farms Three Rivers and Cass City locations. 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 ten varieties in 300' strips and harvested three, 23-ft sections of row for each variety. Our check varieties were 'Lamoka' and 'Snowden' (Tables 3 to 7). For more details on this trial, please reference the 2022 annual report published by Potatoes USA.

C. Fresh Market Trials

Within the fresh market trials, we evaluated 148 primary entries (this does not include entries from Potatoes USA/NFPT trial) which included: 59 russet, 35 red, 40 yellow, 4 novelty, and 10 round white types (Tables 9 and 10). To evaluate selected table-stock lines, we used the following check varieties:
Red: Dark Red Norland
Round White: Reba, Superior
Russet: Russet Norkotah, Silverton Russet, Russet Burbank
Yellow: Yukon Gold
Novelty: Blackberry
We planted all trials with 34" wide rows and 10" in-row seed spacing.

We evaluated most of the fresh market trials as strip trials. These trials consisted of a single 75' strip 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 (Table 11). 2022 was the fourth year conducting an early generation tablestock variety trial with red skin white flesh and yellow skin potato varieties. This trail was planted and harvested like the NFPT trial, and took place at Walther Farms, Inc (Table 12). We planted Walther Farms, Inc. trials trial with three, 15-ft rows and harvested the middle row. We also conducted multi-acre block plantings of promising, non-commercialized trials at Kitchen Farms and Walther Farms Cass City. 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 2022 (Table 1) and evaluated these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Table 2). Below are five superior processing varieties from 2022.

> **N174:** This Cornell variety was evaluated at ten locations in 2022. It had the fourth highest US#1 yield of 580 cwt/A and a total yield of 620 cwt/A. The size breakdown was 93% A sized tubers, six percent B sized tubers, and one percent pickouts. The specific gravity was 1.086, above the trial average of 1.080. Internal quality was good with all defects below ten percent. The fresh chip score was 1.1 with a stem end score of 0.6, below the trial average. The vine vigor and vine maturity were consistent with the trial averages, with scores of 3.8 and 2.8, respectively. The tubers had a flattened oval type and light netted skin.

MSAA260-03: This Michigan State University variety was evaluated at ten locations in 2022. It had a high US#1 yield of 558 cwt/A and high total yield of 592 cwt/A. There were more A-sized tubers present than the trial average, and only four percent B-sized tubers. The specific gravity of 1.082 was slightly above the trial average. The fresh chip quality was good with a color score of 1.2. Internal quality was acceptable with some vascular discoloration, internal brown spot, and brown center observed in 2022. MSAA260-03 had a moderately vigorous vine and mid-season vine maturity. The tubers were blocky with deep apical eyes. It will be evaluated in storage at the Montcalm Research Center during the 2022-2023 storage season.

MSBB008-3: This variety was evaluated at eight locations in 2022. It had a very high US#1 and total yield of 520 cwt/A and 577 cwt/A, respectively. It had a high percentage of A sized tubers, no oversized tubers and few pickouts. The specific gravity of 1.083 was above the trial average of 1.080. The fresh chip score and stem end defect score were both at or below the trial average with good chip quality observed. The tubers had an oval type with thin skin. The vine type was slightly smaller than average with a mid-season maturity. It will be evaluated in storage at the Montcalm Research Center during the 2022-2023 storage season.

MSAA076-6: This Michigan State University variety was evaluated at ten locations in 2022. It had an above average yield of 514 cwt/A and total yield of 611 cwt/A. There were slightly more B sized tubers than average but no oversized tubers, which is an acceptable size profile for the processing industry. Specific gravity was 1.087, above the trial average. Internal quality was acceptable with defects at or slightly above average. The fresh chip color score of 1.1 was good, and the stem end defect score of 0.4 was below the trial average. This variety has a moderately vigorous vine and mid-season vine maturity. The tubers had thin skin, moderate growth crack, and some deeper apical eyes. Some sticky stolons were observed. It will be evaluated in storage at the Montcalm Research Center during the 2022-2023 storage season.

AF6206-3: This University of Maine variety was evaluated by the POP for the first time in 2022 at three locations. It had an above average US#1 yield of 507 cwt/A and total yield of 538 cwt/A. It had 92% A sized tubers, two percent oversized tubers and one percent pickouts. Internal quality was excellent, with only one percent hollow heart observed in 2022. The specific gravity of 1.085 was slightly above the trial average. Chip color and stem end defect ratings were both acceptable. This variety had slightly more common scab tolerance than average, 0.6 vs 0.8. The tubers were uniform with a blocky round to oval type.

B. Potatoes USA/SNAC Int. Chip Trial

In 2022, 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 eight 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 conducted pre-harvest panels for each variety (Tables 7A and B).

The varieties with the highest US#1 yields were W15125-4 and MSZ242-13, with us#1 yields of 566 cwt/A and 379 cwt/A. These two varieties also had the highest percent of US #1 tubers, 93%. The average specific gravity of the trial was 1.082 (Table 3). W15NYR11-13 has the highest incidence of internal defects, with three percent hollow heart and 20% vascular discoloration (Table 4). Samples collected on October 20th were processed by Herr's Foods, Inc. on November 7th. NY163 was ranked second by Herr's (Lamoka, a check variety was ranked first) and had a SFA color of 2 and 8.5% total defects. MSZ242-13 was also ranked highly, with a SNAC color of 3 and 15.4% total defects. W15125-4 was ranked last with a SFA color of 5, 100% total defects, stem end defects, edge color, and scab (Table 5). Black spot bruise assessments demonstrated that W15NYR11-13, MSZ242-13, and MSAFB609-12 were most resistant to black spot bruising, while MSW474-1 and Snowden 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 2022 (Table 8) and assessed these varieties based on yield, specific gravity, internal quality, common scab ratings, and maturity (Tables 9 and 10). The NFPT and Early Generation Tablestock trials screen potato selections under initial evaluation. In 2022, 56 NFPT-designated russet varieties and an additional 10 russet selections were evaluated (Table 11). Continued evaluation of these varieties are determined based on national performance. In total, 85 red skin potato varieties from Cornell University, University of Maine, Michigan State University, Colorado State University, Texas A & M University, and North Dakota State University potato breeding programs were grown in Michigan. Of these, 43 varieties were chosen for continued evaluation in Michigan (Table 12). They were be grown in 15-foot plots in 2023. Below are top performing russet, yellow, red, white, and novelty fresh pack varieties.

Russets

A12327-5VR: This USDA Idaho variety was evaluated at nine locations in 2022. It had the highest yield in the trial, 570 cwt/A US#1 tubers, and 671 cwt/A total yield. The tuber size profile was very large with 34% oversize tubers, much higher than the trial average of 10%, but this may be successfully managed with cultural practices during the growing season. Internal quality was acceptable, with the higher than average hollow heart incidence related to the higher proportion of oversize potatoes. The specific gravity was average for the trial. The tubers were attractive with an appealing russet skin. A few pointed tubers were observed.

AF5707-1: This University of Maine variety was evaluated at eight locations in 2022. It had a very high US#1 yield of 525 cwt/A, with a high percentage of A-sized tubers. The specific gravity was slightly above the trial average. Eleven percent hollow heart and one percent vascular discoloration were observed in 2022. The common scab rating was slightly higher than the trial average, suggesting potential susceptibility to the pathogen. The tubers had an attractive type and appearance as well as a flattened oblong type.

W13A11229-1rus: This variety also had a high total yield of 473 cwt/A with 74% US #1 tubers. Tuber appearance was good with fewer pickouts than average. It had an above average specific gravity of 1.085 and a common scab rating of 0.6. Slightly more hollow heart than average was observed in 2022. This variety had a flattened oblong tuber type and medium russet skin. It was evaluated at eight locations around the state.

CO10085-1RUS: While this variety had a slightly below average yield of 357 cwt/A US#1 tubers, it has continued to display excellent characteristics under evaluation by the Potato Outreach Program. It has a higher than average specific gravity, excellent internal quality, and a vigorous vine. The russet skin and tuber type are consistently appealing. Depending on seed availability, this variety will be evaluated in bulk plantings in 2023.

Yellow Flesh

Columba: This yellow-fleshed variety had the third highest total and US#1 trial yield of 499 and 566 cwt/A, respectively. It produced 82% A-sized tubers and had a lower specific gravity of 1.052. Internal quality was very good with six percent vascular discoloration observed. Columba had a more vigorous vine that matured earlier than average. This variety had a common scab rating of 0.8, and medium yellow flesh. It had smooth, waxy skin, but did not have a consistently uniform tuber type.

Golden Globe: This variety has a consistent attractive appearance with a smooth skin finish and medium yellow flesh. With a US#1 yield of 454 and total yield of 538 cwt/A, this variety produced 82% US#1 tubers. It had an average rating for skin waxiness and yellow flesh color. It had a larger vine type and earlier vine maturity than the trial averages. Golden Globe had good internal quality with 14% vascular discoloration and no other defects observed.

Floridana: This variety had an above average total and US#1 yield, with 83% A-sized tubers. The specific gravity of 1.063 was below the trial average. Internal quality was good with two percent hollow heart and 11% vascular discoloration. Floridana is susceptible to common scab but had a bright appearance and a flattened oval to oblong tuber type. Both skin waxiness and yellow flesh color were higher than the trial averages. A trace of heat knobs was observed in 2022.

Constance: This variety was first evaluated at seven locations in 2022. It has an above average US#1 and total yield, and a high percentage of A-sized tubers. The size profile was consistent with the average of all yellow flesh tubers evaluated in 2022. Internal quality was excellent, with only two percent vascular discoloration observed. The vine vigor and maturity were consistent with the trial averages. The tubers had a flattened oval type and attractive appearance.

Red Skin

NDAF113484B-1: This North Dakota selection was the highest yielding variety in the 2022 red skin potato trial with a US #1 yield of 431 cwt/A and a total yield of 473 cwt/A. It was evaluated at seven locations in 2022 and had 90% US #1 tubers, well above the 75% average for red skin varieties. NDAF113484B-1 had a specific gravity of 1.061, lower than the trial average of 1.069. It had good internal quality with only ten percent vascular discoloration and no other defects. This mid-season variety had a larger vine type and a common scab rating consistent with the trial average. It had a round to oval tuber type, consistent dark red skin color, and slightly prominent eyes.

NDA050237B-1R: This variety had the third highest US #1 yield of 417 cwt/A and a specific gravity of 1.064. It had a high proportion of A-sized tubers and fewer B-sized tuber than average. Its internal quality was generally good with eleven percent vascular discoloration. This variety had a flattened round tuber type with uniform skin color and slight skinning. It had a late season maturity and moderately vigorous vine. Skin color was a deep, attractive red, and was moderately waxy. Slight sticky stolons were observed, likely due to full season maturity requirements.

CO99076-6R: This early maturing Colorado variety produced attractive, uniform tubers with deep red skin. It had a US #1 yield of 399 cwt/A, above the trial average of 325 cwt/A. CO99076-6R had a larger size profile with only seven percent B size tubers. It had good internal quality with six percent vascular discoloration when observed at seven locations in 2022. Skin color and skin color uniformity were both rated above average, while silver scurf was lower than average.

NDAF13296Y-4: This variety had a high US#1 yield of 351 cwt/A and total yield of 379 cwt/A in 2022 at three locations. It had a high proportion of A-sized tubers, and fewer pickouts than average. The specific gravity of 1.076 was above average for 2022. Internal quality was excellent, with only seven percent vascular discoloration observed and no other defects. The tubers were blocky and round to oval. Some sticky stolons were observed, although the variety displays mid-season maturity. Skin color was rated very uniform, and waxiness and color scores were consistent with the average.

Round White

Volare: This variety had the highest yield in 2022with 614 cwt/A US#1 tubers and a total yield of 789 cwt/A. It also had the highest yield of round white varieties in 2021.Volare produced 88% A-sized tubers, significantly higher than the trial average. It had an attractive type and skin, with an above average skin waxiness rating. The tubers were bright and thin skinned, and were round to oval. Internal quality was acceptable with internal defects near the trial average. The specific gravity of 1.056 was very low.

Sifra: This variety was evaluated by the Potato Outreach Program for the first time in 2022. It had the second highest yield of round white potatoes, with 580 cwt/A US#1 tubers and 690 cwt/A total yield. Sifra displayed a bright appearance with thin skin, although a trace of knobs and misshapen tubers was observed at three locations. Common scab susceptibility was average for 2022. The specific gravity of 1.073 was higher than the trial average.

AF6735-2: This University of Maine selection had a lower than average yield in 2022, but a very good appearance with bright skin and a consistent round type when evaluated at two locations. While the US#1 yield of 355 cwt/A was lower than average, there were 87% A-sized tubers. The specific gravity and common scab score were consistent with the trial averages. Internal quality was variable, with 15% vascular discoloration and ten percent internal brown spot. Further evaluation will determine if this variety has commercialization potential in Michigan.

Novelty

Blackberry: This Michigan State University selection had purple skin and flesh, and an above average yield of 487 cwt/A US #1 tubers. It produced 79% A sized tubers and 16% B sized tubers. Blackberry had no internal defects but was only evaluated at three locations in 2022. The purple skin was a uniform dark color, but severe silver scurf was observed. Some tubers had chimeral eyes with white pigmentation, while most other tubers had consistent purple skin. Blackberry is less susceptible to common scab than average and had mid-season maturity.

Table 1. 2022 Chip Processing Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
AC13126-1Wadg	USDA Idaho	1.0	Heavier skin, inconsistent type
AF5933-4	Eva x AF4386-16	0.9	Round to oval type, good internal quality
AF5973-3	Pike x Mainechip	0.6	Bright thin skin, moderate hollow heart, good specific gravity
AF6165-9	Beacon Chipper x AF290-5	1.2	Moderate hollow heart, average yield, common scab susceptible
AF6200-4	Sebec x Tundra	1.7	Above average yield, good internal quality, lower specific gravity
AF6200-7	Sebec x Tundra	0.2	Blocky round type, deep apical ends, high specific gravity, earlier vine maturity
AF6206-3	AF4386-16 x Lamoka	0.6	Above average yield, good specific gravity and internal quality
AF6206-5	AF4386-16 x Lamoka	1.3	Very high specific gravity, good internal quality, severe growth crack
AF6522-1	Lamoka x NY121	1.5	Low specific gravity, earlier vine maturity, average yield
AF6526-7	Pike x AF5040-8	2.3	Below average yield, thin skin, smaller vine type
AF6550-2	NDAF102629C-4 x AF5040-8	0.9	Less uniform type, moderate growth crack, below average yield

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AF6552-2	NY148 x Lamoka	1.2	Above average yield, blocky round type, smaller vine type
AF6555-2	NY148 x MSR127-2	0.7	Recessed stem ends, deeper apical eyes, stem end defect apparent when chipped
AF6565-8	WAF10131-19 x MSR127-2	0.5	High yield, good internal quality, smaller vine type
AF6567-4	WAF10192-3 x MSR127-2	0.8	Above average specific gravity, slight hollow heart, moderate growth crack
AF6601-2	NY121 x Lamoka	1.2	Below average specific gravity, nice round shape, light skin, good internal quality
AF6603-5	NY121 x MSR127-2	1.4	Smaller vine type, deeper eyes, compressed shape, average yield
AF6717-1	AF4573-2 x MSAFB26-5	1.5	Very low yield, low specific gravity, small vine type
Atlantic	Wauseon x Lenape	0.5	Check for fresh chip varieties, severe hollow heart, blocky flattened type
B3296-3	Mirton Pearl x B1416-2	1.3	Thin skin, sticky stolons, lower specific gravity, slight pinkeye
B3317-1	BNC318-9 x B2869-15	1.3	Bright thin skin, nice appearance, moderate hollow heart and vascular discoloration

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
BNC816-7	Lamoka x NC41-1	0.3	Below average yield, low specific gravity, flattened round type
CO12293-1W	CO02024-9W x ND7519-1	1.1	Bright thin skin, blocky round type, lower specific gravity, average yield
CO13232-25W	AC00206-2W x CO02024-9W	0.2	Flattened round to oval type, good internal quality, average yield
COTX12235-2W	AC00206-2W x AC03433-1W	1.0	Smaller size profile, low yield, good internal quality, smaller vine type, earlier vine maturity
Lady Liberty (NY152)	B38-14 x Marcy	0.9	Above average yield, lower specific gravity, small flattened round type, bright appearance, trace pink pigmentation around some tuber eyes
Lamoka (NY139)	NY120 x NY115	1.3	Check for storage chipping varieties, oval type, some pointed tubers, good specific gravity
Mackinaw (MSX540-4)	Saginaw Chipper x Lamoka	0.5	Flat round type, deeper eyes, good internal quality, high specific gravity, average yield
Manistee	Snowden x MSH098-2	0.3	Very high yield, good specific gravity, excellent internal quality, smaller vine type
MSAA076-6	MSR127-2 x MSS297-3	0.7	Above average yield and specific gravity, moderate growth crack, thin skin, slight internal brown spot

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
MSAA252-7	NY148 x MSQ089-1	1.0	Very high yield, low specific gravity, moderate internal brown spot, full season vine maturity
MSAA260-03	MSQ086-3 x Atlantic	1.1	High yield, blocky type, average specific gravity, moderate sheep nose
MSAFB609-12	NY148 x MSQ086-3	1.1	Good internal quality, below average yield, attractive type and appearance
MSAFB635-15	NYH15-5 x MSS297-3	1.3	Blocky round type, smaller tuber size profile, good internal quality, above average specific gravity
MSBB008-03	Atlantic x MSR127-2	0.9	Light netted skin, above average yield, smaller vine type, oval type
MSBB058-1	NY148 x MSR127-2	0.9	Very high specific gravity, average yield, moderate growth crack, less uniform type
MSBB610-13	NY148 x MST096-2Y	0.4	Smaller vine type, flattened blocky round tuber type, good internal quality, average yield
MSBB614-11	Saginaw Chipper x MSR127-2	1.0	Below average yield and specific gravity, good internal quality, smaller vine type, common scab susceptible
MSBB614-15	Saginaw Chipper x MSR127-2	0.4	Blocky oval type, netted skin, average yield and specific gravity, good internal quality

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
MSBB626-11	Saginaw Chipper x Kalkaska	0.2	Thin skin, variable tuber type, above average yield, above average stem end reaction when chipped
MSBB630-2	Lady Liberty x Kalkaska	0.5	Good internal quality, nice type and appearance, average yield and specific gravity
MSBB636-11	Lady Liberty x MST096-2Y	0.6	Average yield, below average specific gravity, smaller vine type, moderate vascular discoloration
MSCC009-1	Michigan State University	0.3	Severe growth crack, high yield, lower specific gravity, severe internal brown spot, larger vine type
MSDD084-19	NY148 x M5	0.6	Flat blocky oval type, severe internal brown spot, above average yield, lower specific gravity
MSDD088-1	NY154 x MSQ086-3	0.4	High yield, very low specific gravity, smaller vine type, moderate vascular discoloration, light netted skin
MSDD089-2	NY154 x MSR127-2	0.5	Below average yield and specific gravity, good internal quality, very small vine type, early vine maturity
MSDD219-2	Michigan State University	0.4	Below average yield and specific gravity, attractive skin, variable type, darker than average chip color

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
MSDD244-05	Mackinaw x MSR127-2	0.5	Average yield, attractive type, above average specific gravity, less common scab susceptible than average
MSDD249-9	Michigan State University	0.7	Average yield and specific gravity, good internal quality, medium netted skin, flat blocky round type
MSDD372-07	NY148 x Missaukee	0.6	Very high specific gravity, above average yield, moderate black scurf, uniform tuber type, stem end defect present in chips
MSDD376-4	NY148 x MSV033-1	0.4	Heavier netted skin, average yield, good internal quality, above average specific gravity
MSDD553-01	Mackinaw x MSQ086-3	0.7	Flat round type, thin skin, above average yield and specific gravity, slight vascular discoloration
MSEE031-3	MSZ219-14 x Lamoka	0.2	Attractive blocky tuber type, average yield and specific gravity, less common scab susceptible
MSFF097-6	MSR127-2 x MSCC725-174	0.4	Uniform round tuber type, above average yield, average specific gravity, darker chips than average
MSW474-1	MSN190-2 x MSP516-A	0.6	Attractive round shape, consistent type, good internal quality, average yield, smaller tuber size profile

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
MSZ242-13	MSR169-8Y x MSU383-A	0.5	Medium netted skin, blocky round type, good internal quality, smaller vine type, average yield, very high specific gravity, earlier vine maturity
NDAF14188-5	ND860-2 x Waneta	1.0	Very high yield, below average specific gravity, moderate hollow heart, very large vine type, recessed stem ends, flattened tuber type
NDTX14362AB-1W	ND102809AB-2 x ND028984B-1	1.5	Very low yield with smaller tuber size profile, good internal quality, large vine type, early maturing plants, attractive tubers with bright skin
NDTX1482YB-1W	Eva x Missaukee	1.8	Low yield and small tuber size profile, excellent internal quality, small early maturing vines, above average specific gravity
NY163	NYE50-8 x NYE48-2	0.7	Bright thin skin, trace sticky stolons, average yield and specific gravity, good internal quality
NY168	NY148 x E48-2	1.1	Flat round type, above average specific gravity, below average yield, good internal quality, more common scab susceptible than average
NY174	NY148 x E48-2	0.3	Above average yield and specific gravity, larger vine type, flat round to oval tubers with bright netted skin

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
NY175	Lady Liberty x NYF31-1	0.8	Round blocky type, thin skin, good internal quality, average yield, below average specific gravity, nice appearance
NYR1-7	Andover x Lady Liberty	1.0	Bright thin skin, average yield and specific gravity, larger vine type, mid-season vine maturity, common scab susceptible
NYS18-4	NY156 x F31-3	0.6	Moderate hollow heart, light netted skin, above average yield, below average specific gravity
NYS37-2	K31-4 x F31-3	0.7	Below average yield, average specific gravity, good internal quality, earlier vine maturity, flat round tuber type
NYT11-3	Lady Liberty x M18-2	0.6	Average yield, below average specific gravity, smaller vine type, mid-season vine maturity, bright skin with slight skinning
NYT19-1	L1-7 x NY158	0.5	Blocky round type, average yield, good internal quality, less stem end defect than average, earlier vine maturity
NYT22-1	L8-12 x Atlantic	0.9	Above average yield, average specific gravity, very early vine maturity, uniform tuber type, slight vascular discoloration
NYT3-3	Lamoka x L2-12	0.7	Average yield, very low specific gravity, moderate vascular discoloration, less uniform type, light netted skin

2022 Processing Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
NYT7-5	McBride x NY158	0.3	Below average specific gravity, good internal quality, smaller tuber size profile, high yield, slight alligator hide
Petoskey (MSV030-4)	Beacon Chipper x MSG227-2	0.7	Below average yield, trace growth crack, heavier netted skin, smaller vine type, good internal quality
Sinatra	Hanse Seed	1.5	Very low yield and small tuber size profile, full season maturity, oval to oblong tuber type, good internal quality
Snowden (W855)	B5141-6 x Wischip	1.9	Check variety for storage trials, above average yield and specific gravity, uniform round type with medium netted skin, common scab succeptible
TX12484-2WCZ	TX08402 x NDTX059828-2W	0.5	Above average yield and average specific gravity, prominent lenticels, flat blocky type, moderate internal defects
TX12484-3WCZ	TX08402 x NDTX059828-2W	0.0	Below average yield and specific gravity, oval to oblong type, thin skin, moderate vascular discoloration
TX17846-1W	CO07070-10W x NDTX091908AB-2W	0.0	Below average yield and specific gravity, good internal quality, smaller type, thin skin
W15125-4	Atlantic x W10670-3	2.0	Above average yield, larger vine type, blocky round type, moderate sticky stolons, common scab susceptible

2022 Processing varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
W15NYR11-13	NY158 x NYF31-3	1.3	Above average yield, attractive type, moderate growth crack, larger vine type, moderate hollow heart
WAF16107-2	MSX540-4 x Tundra	0.6	Below average yield, good internal quality, inconsistent type, prominent eyes, average specific gravity

*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. 2022 Michigan Statewide Chip Processing Potato Variety Trials
Overall Averages - Thirteen 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
MSAA252-7[bdl]	711	744	96	4	88	8	0	1.072	1.2	3	20	30	0	1.0	0.5	3.3	3.3	moderate pink eye, medium netted skin, round type
Manistee[ef]	711	744	95	4	95	0	1	1.086	1.0	0	0	0	0	0.3	0.5	1.8	2.5	uniform blocky round type, heavier netted skin
NDAF14188-5[a]	613	637	96	4	93	3	0	1.076		20	0	0	0	1.0		5.0	3.0	flat type, recessed stem ends
NY174[abcdefghlm]	580	620	93	6	93	0	1	1.086	1.1	1	8	8	0	0.3	0.6	3.8	2.8	flat round to oval type, light netted skin
MSDD088-1[hm]	564	624	90	9	90	0	1	1.071	1.0	0	18	0	0	0.4	0.7	2.5	3.0	flat round to oval type, light netted skin
AF6565-8[m]	558	610	92	8	91	1	0	1.082	1.0	0	0	0	0	0.5	0.6	2.2	3.0	uniform round type, light skin
MSAA260-03[abcdefghlm]	558	592	95	4	93	2	1	1.082	1.2	0	10	14	9	1.1	0.9	3.3	2.9	blocky type, deep apical eyes, moderate sheep nose
W15125-4[cdjm]	557	609	92	7	91	1	1	1.082	1.4	3	5	8	0	2.0	1.5	3.6	3.0	blocky round type, moderate sticky stolons
NYS18-4[agm]	556	597	93	6	91	2	1	1.076	1.0	22	0	0	0	0.6	0.7	3.5	2.7	flattened round type, light netted skin
TX12484-2WCZ[f]	551	607	90	4	88	2	6	1.079	1.0	10	20	0	10	0.5	1.3	4.5	2.0	prominent lenticels, flat blocky type, anthocyanin pigmentation
W15NYR11-13[abfhjlm]	532	613	86	12	86	0	2	1.075	1.0	1	13	4	0	1.3	0.6	3.5	3.1	attractive type, moderate growth cracks
MSBB008-3[abcdfhlm]	520	577	91	8	91	0	1	1.083	1.1	1	9	8	1	0.9	0.6	2.9	2.8	light netted skin, oval type
MSAA076-6[abcdefghlm]	514	611	84	13	84	0	3	1.087	1.1	4	9	14	1	0.7	0.4	3.3	2.7	moderate growth crack, thin skin, deeper apical eyes
AF6200-4[m]	512	557	92	6	91	1	2	1.078	1.0	0	0	0	0	1.7	1.3	2.5	2.8	flat oval type, heavier netted skin
MSCC009-1[bdl]	510	567	89	8	89	0	3	1.074	1.2	3	20	30	0	0.3	0.4	3.5	2.8	severe growth crack, trace alligator hide
NYT22-1[cdfg]	507	593	84	14	83	1	2	1.079	1.4	5	13	0	3	0.9	0.6	3.4	1.9	round to oval type, trace growth crack, uniform type
Lady Liberty[abcdefglm]	507	576	87	12	87	0	1	1.076	1.1	1	14	5	0	0.9	0.6	3.4	2.7	small flat round type, medium netted skin, bright appearance
AF6206-3[agm]	507	538	94	5	92	2	1	1.085	1.2	1	0	0	0	0.6	0.8	3.4	2.9	round to oval type
AF6552-2[agm]	500	528	95	4	93	2	1	1.081	1.2	0	7	0	0	1.2	1.3	2.9	3.0	blocky round type, medium netted skin
NYT7-5[bfg]	494	594	82	18	82	0	0	1.073	1.0	0	10	0	0	0.3	0.4	2.5	2.5	small round type, slight alligator hide
MSDD084-19[abcdefghklm]	493	547	89	10	87	2	1	1.075	1.2	7	8	33	0	0.6	0.7	3.0	2.8	flat blocky oval type, moderate skinning
MSDD553-01[agh]	492	559	88	12	87	1	0	1.083	1.5	7	10	0	0	0.7	1.0	2.7	2.7	flat round type, thin skin
Snowden[acefghjkm]	**490**	**560**	86	**13**	**86**	**0**	**1**	**1.088**	**1.1**	**7**	**13**	**1**	**0**	**1.9**	**0.7**	**3.3**	**2.7**	**uniform round type, medium netted skin**
MSBB626-11[abcdel]	489	533	91	7	91	0	2	1.079	1.3	7	8	5	5	0.2	1.1	3.5	2.6	inconsistent appearance, thin skin
MSDD372-07[gm]	482	545	88	12	88	0	0	1.092	1.0	0	2	0	0	0.6	1.1	3.3	2.8	moderate black scurf, uniform type
MSFF097-6[hm]	478	533	90	9	89	1	1	1.082	1.4	3	10	0	0	0.4	0.9	3.1	2.7	smaller uniform round type
MSDD249-9[abcdfglm]	474	510	93	7	92	1	0	1.078	1.2	0	6	0	0	0.7	0.8	3.5	2.6	flat blocky round type, medium netted skin
NY175[abcdefghlm]	468	547	84	15	84	0	1	1.077	1.2	0	3	2	0	0.8	0.8	3.5	2.6	round blocky type, light thin skin, bright appearance
MSEE031-3[aghlm]	464	507	91	8	91	0	1	1.080	1.3	0	10	1	0	0.2	0.7	3.5	2.7	nice blocky appearance, thin skin
Mackinaw[abcdefghiklm]	464	504	91	8	90	1	1	1.085	1.2	0	9	0	1	0.5	0.6	2.8	2.9	flat round type, slight deep apical eyes
MSAFB635-15[abcdefghijklm]	463	568	81	19	81	0	0	1.085	1.1	0	6	1	0	1.3	0.6	3.2	2.7	blocky round type, slight growth crack
NYT3-3[blm]	463	547	85	12	85	0	3	1.072	1.0	0	17	0	0	0.7	0.3	3.3	2.7	non uniform type, light netted skin
MSBB636-11[bcdefghlm]	463	507	91	7	89	2	2	1.073	1.0	6	11	0	0	0.6	0.3	1.7	2.5	slight alligator hide, blocky round type
MSBB630-2[h]	461	525	88	9	88	0	3	1.083	1.5	0	0	0	0	0.5	0.3	2.0	2.0	medium round tuber type, light netted skin, nice appearance
MSBB610-13[fhm]	458	481	95	4	93	2	1	1.079	1.0	0	0	0	0	0.4	0.6	2.3	2.3	flattened blocky round type
NYT19-1[fg]	456	528	86	13	85	1	1	1.078	1.0	0	5	0	0	0.5	0.4	3.3	2.3	blocky round type, trace skinning
MSBB058-1[acfhlm]	456	506	90	7	89	1	3	1.090	1.0	3	6	2	0	0.9	0.3	2.9	2.7	moderate growth crack, less uniform type
MSW474-1[acefghjm]	454	538	83	16	83	0	1	1.083	1.1	0	3	0	0	0.6	0.8	3.4	3.0	nice round type, consistent skin, trace pointed tubers
B3296-3[bd]	454	528	87	8	84	3	5	1.077	1.0	0	20	10	0	1.3	0.8	3.8	2.8	thin skin, sticky stolons, slight pinkeye
CO13232-25W[afg]	450	516	86	13	85	1	1	1.075	1.0	3	7	0	0	0.2	0.8	3.7	2.5	flat round to oval type, light netted skin
AF6603-5[ghm]	448	501	89	10	89	0	1	1.083	1.5	8	17	0	7	1.4	0.7	2.4	2.7	deep apical eyes, slightly compressed shape
MSZ242-13[abcdefghjklm]	445	481	92	6	88	4	2	1.092	1.2	3	4	2	0	0.5	0.6	2.8	2.4	medium netted skin, blocky round type
CO12293-1Wadg[abcdfghlm]	442	494	90	7	89	1	3	1.074	1.1	1	12	1	0	1.1	0.7	3.1	2.8	bright thin skin, blocky round type
NY168[abcdefghijklm]	436	504	86	12	82	4	2	1.086	1.1	4	6	2	2	1.1	0.9	2.8	3.0	flat round type, some purple pigmentation
AF6555-2[agm]	435	478	90	10	90	0	0	1.081	1.0	1	8	3	0	0.7	1.4	3.1	2.9	recessed stem ends, deeper apical eyes

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR[2]	OTF CHIP SCORE[3]	RAW TUBER QUALITY[4] (%) HH	VD	IBS	BC	COMMON SCAB RATING[5]	SED SCORE[6]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
MSDD244-05[efgh]	429	467	92	7	92	0	1	1.083	1.0	3	3	0	0	0.5	0.5	2.6	2.5	nice appearance, slight deep apical eyes
AF6200-7[agm]	429	452	95	4	92	3	1	1.091	1.3	0	4	7	0	0.2	0.8	3.3	2.4	blocky round type, deep apical ends
AF6206-5[agm]	427	517	82	9	82	0	9	1.094	1.0	0	0	0	0	1.3	0.7	3.2	2.7	severe growth crack, moderate alligator hide
AF6601-2[agm]	427	482	88	10	88	0	2	1.074	1.2	0	0	0	0	1.2	1.0	3.4	2.6	attractive round shape, light skin
MSDD376-4[hm]	422	467	91	8	90	1	1	1.084	1.3	0	10	0	0	0.4	0.6	2.9	2.7	flat round tuber type, medium to heavy netted skin
NYR1-7[abcdefghlm]	420	489	85	14	85	0	1	1.080	1.0	3	10	6	0	1.0	0.6	3.6	2.8	nice appearance, light skin, round to oval type
NYT11-3[blm]	417	474	86	13	86	0	1	1.077	1.0	3	16	7	0	0.6	0.4	2.9	2.8	bright skin, slight skinning, oval to oblong type
AF6567-4[agm]	414	482	85	8	84	1	7	1.087	1.2	12	7	0	0	0.8	0.5	3.2	2.9	misshapen tubers, moderate growth crack
B3317-1[bd]	407	469	87	11	86	1	2	1.080	1.0	20	20	1	0	1.3	1.0	3.3	2.5	bright thin skin, nice appearance
MSBB614-15[ghm]	407	441	92	3	90	2	5	1.082	1.3	2	7	0	0	0.4	0.7	1.9	2.6	blocky oval type, heavy netted skin
Atlantic[bdl]	**405**	**466**	87	**9**	**86**	**1**	**4**	**1.082**	**1.3**	**57**	**20**	**7**	**0**	**0.5**	**1.0**	**3.5**	**3.0**	**non-uniform type, blocky flattened tubers**
AF6522-1[agm]	402	535	75	24	75	0	1	1.075	1.0	0	3	3	1	1.5	1.0	3.3	2.2	flaky skin, trace sticky stolons
AF5973-3[agm]	396	441	89	10	88	1	1	1.085	1.2	13	2	3	0	0.6	0.7	3.1	2.6	bright thin skin, uniform blocky tubers
AF6550-2[agm]	395	462	84	9	84	0	7	1.081	1.2	7	2	0	0	0.9	0.9	3.5	2.6	moderate growth cracks, less uniform type
NY163[abcdefghijklm]	393	475	81	17	80	1	2	1.081	1.0	0	11	0	0	0.7	0.3	2.7	2.7	bright thin skin, round type, trace sticky stolons
WAF16107-2[agm]	386	423	91	7	90	1	2	1.078	1.2	1	1	3	0	0.6	0.4	3.2	2.4	inconsistent type, prominent eyes
Petoskey[abcdefglm]	381	434	87	11	87	0	2	1.084	1.2	1	8	1	0	0.7	0.8	2.6	2.6	trace growth crack, moderate alligator hide, heavy skin
Lamoka[acefgjm]	**377**	**417**	90	**8**	**90**	**0**	**2**	**1.083**	**1.1**	**1**	**10**	**2**	**0**	**1.3**	**0.9**	**3.0**	**2.6**	**oval type, pointed tubers in pickouts**
MSAFB609-12[abcdfghijklm]	365	439	82	18	82	0	0	1.082	1.0	0	8	1	0	1.1	0.5	2.9	2.7	attractive uniform round tuber type, light netted skin
MSBB614-11[g]	363	401	91	9	91	0	0	1.071		0	0	0	0	1.0		2.5	3.0	small round type, uniform medium netted skin
AF6165-9[agm]	354	427	82	16	82	0	2	1.086	1.0	26	3	0	0	1.2	0.9	3.2	2.8	flat round type, light netted skin
AF5933-4[agm]	339	404	82	17	82	0	1	1.082	1.3	0	0	0	0	0.9	1.3	3.4	2.4	nice round to oval type
AC13126-1Wadg[afg]	338	376	89	8	88	1	3	1.077	1.2	10	7	0	0	1.0	1.1	2.8	2.3	heavier skin, inconsistent tuber type
MSDD219-2[abcgl]	333	394	84	11	84	0	5	1.073	1.7	2	4	2	0	0.4	1.0	3.0	2.7	attractive skin, less uniform type, trace pointed tubers
MSDD089-2[gh]	328	353	93	6	91	2	1	1.076	1.0	0	0	0	0	0.5	0.1	1.5	2.0	blocky type, medium netted skin
AF6526-7[ghm]	319	366	85	14	85	0	1	1.081	1.0	11	7	0	0	2.3	0.5	2.4	2.7	thin skin, flat oval type
NYS37-2[ghm]	308	345	90	9	90	0	1	1.083	1.0	0	0	2	0	0.7	0.7	2.6	2.3	flat round type, slight growth crack
BNC816-7[bd]	299	378	80	17	80	0	3	1.070	1.0	0	15	10	0	0.3	0.8	4.0	2.5	flattened round type
TX12484-3WZC[f]	297	360	82	17	82	0	1	1.069	1.0	10	20	0	0	0.0	0.6	2.5	3.0	oval to oblong type, thin skin
TX17846-1W[af]	212	349	62	35	62	0	3	1.071	1.0	0	0	0	0	0.0	0.6	4.0	2.5	small round type, thin skin
NDTX1482YB-1W[cf]	212	307	66	32	66	0	2	1.084	1.0	0	5	0	0	1.8	0.2	2.3	1.8	round type, thin skin, nice appearance
COTX12235-2W[f]	198	353	56	44	56	0	0	1.074	1.0	0	10	0	0	1.0	1.0	2.5	2.0	small, uniform round type
NDTX14362AB-1W[cf]	169	250	64	35	64	0	1	1.077	1.0	0	5	0	0	1.5	0.2	4.3	2.0	smaller round type, bright appearance
AF6717-1[g]	141	208	68	32	68	0	0	1.070	1.0	10	20	0	0	1.5	1.2	2.0	2.5	round type, light netted skin
Sinatra[h]	132	308	43	53	43	0	4	1.089	1.0	0	0	0	0	1.5	0.1	3.5	3.5	flat oval to oblong tuber type, thin skin
MEAN	433	495	86	12	85	1	2	1.080	1.1	4	8	3	0	0.8	0.7	3.1	2.6	

2022 Chip Variety Trial Sites
[a]4-L Farms, Storage Trial
[b]Black Gold Farms, Fresh Trial
[c]Hampton Potato Growers, Storage Trial
[d]Lennard Ag. Co., Fresh Trial
[e]Lennard Ag. Co., Select Trial
[f]Lennard Ag. Co., Storage Trial
[g]Main Farms, Storage Trial
[h]Montcalm Research Center Box Bin Trial
[i]Sandyland Farms SNAC Replicated Storage Trial
[j]Sandyland Farms, Set 1 Storage Trial
[k]Verbrigghe Farms, Fresh Chip Trial
[l]Walther Farms, Fresh Trial
[m]Walther Farms, Replicated Storage Trial

[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 lesions

[6]**SED (STEM END DEFECT) SCORE**
0: No stem end defect
1: Trace stem end defect
2: Slight stem end defect
3: Moderate stem end defect
4: Severe stem end defect
5: Extreme stem end defect

[7]**VINE VIGOR RATING**
Date: Variable
Rating 1-5
1: Slow emergence
5: Early emergence (vigorous vines, some flowering)

[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
W15125-4 [a]	566	610	93	7	92	1	0	1.082
Snowden [b]	**452**	**540**	**84**	**16**	**84**	**0**	**0**	**1.085**
Lamoka [c]	**383**	**450**	**85**	**14**	**85**	**0**	**1**	**1.080**
MSZ242-13 [c]	379	408	93	6	93	0	1	1.093
MSAFB635-15 [cd]	360	477	76	24	76	0	0	1.084
W15NYR11-13 [cd]	357	437	82	17	82	0	1	1.072
MSAFB609-12 [cd]	355	436	82	18	82	0	0	1.080
NY163 [cd]	348	427	81	19	81	0	0	1.080
NY168 [cd]	342	436	78	21	78	0	1	1.086
MSW474-1 [d]	301	388	78	22	78	0	0	1.081
MEAN	**384**	**461**	**83**	**16**	**83**	**0**	**0**	**1.082**
ANOVA p-value	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**<.0001**	**0.4711**	**0.0212**	**<.0001**
LSD	**59.2**	**61.5**	**5.0**	**5.1**	**5.1**	**-**	**0.7**	**0.004**

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

Table 4. At-Harvest Tuber Quality. Sandyland Farms, Howard City, Michigan.				
	Raw Tuber Quality[1] (%)			
Entry	HH	VD	IBS	BC
W15125-4	13	0	0	0
Snowden	**10**	**10**	**0**	**0**
Lamoka	**0**	**16**	**0**	**0**
MSZ242-13	0	0	0	0
MSAFB635-15	0	3	0	0
W15NYR11-13	3	20	0	0
MSAFB609-12	0	3	0	0
NY163	0	0	0	0
NY168	3	3	0	0
MSW474-1	0	10	0	0
MEAN	**3**	**7**	**0**	**0**
ANOVA P-value	**0.0094**	<.0001	**-**	**-**
LSD	**7.6**	**6.2**	**-**	**-**

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

Table 5. Post-Harvest Chip Quality[1] for the 2022 SNAC Trial at Sandyland Farms

Rank	Entry	SNAC[2] Color	Specific Gravity	Percent Chip Defects[3] Internal	External	Total
1	**Lamoka**	**3.0**	**1.080**	**5.2**	**6.9**	**12.1**
2	NY163	2.0	1.075	0.0	8.5	8.5
3	**Snowden**	**3.0**	**1.084**	**1.9**	**4.7**	**6.6**
4	MSZ242-13	3.0	1.086	1.1	14.3	15.4
5	MSAFB609-12	2.0	1.077	2.9	10.3	13.2
6	MSAFB635-15	3.0	1.079	2.5	12.3	14.8
7	W15NYR11-13	4.0	1.074	22.5	9.5	32.0
8	NY168	3.0	1.081	2.6	40.0	42.6
9	MSW474-1	4.0	1.077	0.0	18.0	18.0
10	W15125-4	5.0	1.080	60.0	40.0	100.0

[1] Samples collected October 20th and processed by Herr Foods, Inc., Nottingham, PA on November 7th 2022

[2] SNAC 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 ranking: 1(best) to 9 (worst)

Table 6. Black Spot Bruise Test for the 2022 SNAC Trial at Sandyland Farms

Entry	A. Check Samples[1] # of Bruises Per Tuber 0	1	2	3	4	5	Total Tubers	Percent Bruise Free	Average Bruises Per Tuber	B. Simulated Bruise Samples[2] # of Bruises Per Tuber 0	1	2	3	4	5	Total Tubers	Percent Bruise Free	Average Bruises Per Tuber
W15NYR11-13	19	6	0	0	0	0	25	76	0.2	11	11	3	0	0	0	25	44	0.7
NY163	16	8	1	0	0	0	25	64	0.4	13	6	4	3	0	0	26	50	0.9
MSZ242-13	14	6	3	2	0	0	25	56	0.7	8	8	8	1	0	0	25	32	1.1
MSAFB609-12	10	11	4	0	0	0	25	40	0.8	4	9	9	3	0	0	25	16	1.4
Lamoka	11	9	5	0	0	0	25	44	0.8	6	7	7	3	2	0	25	24	1.5
MSAFB635-15	13	8	3	1	0	0	25	52	0.7	5	9	5	2	1	3	25	20	1.8
NY168	8	13	4	0	0	0	25	32	0.8	3	8	7	6	0	1	25	12	1.8
W15125-4	2	8	8	5	2	0	25	8	1.9	0	7	6	3	5	2	23	0	2.5
MSW474-1	5	4	5	5	0	4	23	22	2.1	1	5	4	8	3	3	24	4	2.7
Snowden	12	4	5	3	1	0	25	48	1.1	1	1	4	6	6	7	25	4	3.4

[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 2022 SNAC Trial at Sandyland Farms, Taken on 8/15/2022						
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Average[5] Tuber Weight
Lamoka	**1.081**	**0.004**	**0.854**	**75**	**100**	**3.73**
MSAFB609-12	1.075	0.003	0.645	100	100	3.46
MSAFB635-15	1.085	0.002	0.301	100	90	2.80
MSW474-1	1.081	0.003	0.538	100	100	2.33
MSZ242-13	1.088	0.001	0.806	90	90	4.84
NY163	1.085	0.002	0.632	75	75	4.52
NY168	1.093	0.002	0.716	80	90	2.56
Snowden	**1.082**	**0.001**	**0.492**	**100**	**100**	**2.77**
W15125-4	1.081	0.054	1.877	90	90	5.35
W15NYR11-13	1.076	0.054	1.754	100	100	3.40

Table7B. Pre-Harvest Panel for the 2022 SNAC Trial at Sandyland Farms, Taken on 8/29/2022						
Entry	Specific Gravity	Glucose[1] %	Sucrose[2] Rating	Canopy Rating[3]	Canopy Uniform.[4]	Average[5] Tuber Weight
Lamoka	**1.082**	**0.002**	**0.701**	**75**	**75**	**5.48**
MSAFB635-15	1.087	0.001	0.565	75	75	3.33
MSW474-1	1.080	0.003	0.348	75	75	3.12
MSZ242-13	1.087	0.001	1.262	85	75	5.05
NY163	1.085	0.000	0.469	60	50	3.26
NY168	1.089	0.002	0.424	75	100	3.37
Snowden	**1.084**	**0.010**	**0.335**	**75**	**75**	**3.44**
W15125-4	1.080	0.003	0.495	80	75	3.92
W15NYR11-13	1.081	0.003	0.722	90	75	3.94

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. 2022 Russet and Tablestock Variety Descriptions

Russet Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
Goldrush	ND450-3Rus x Lemhi Russet	0.0	Below average yield, lower specific gravity, smaller tuber size profile, common scab resistant, earlier vine maturity, longer type, heavier skin
Ranger Russet (A7411-2)	Butte x A6595-3	0.8	Long tubular type, deeper eyes, above average specific gravity, high total yield, common scab susceptible, many small tubers
Reveille Russet (ATX91137-1Rus)	Bannock Russet x A83343-12	0.1	Above average yield, below average specific gravity, good internal quality, uniform oblong type
Russet Burbank	Unknown	0.1	Check variety, high percentage of pickouts, excellent internal quality, common scab resistant, many misshapen tubers
Russet Norkotah	ND9526-4Rus x ND9687-5Rus	0.2	Check variety, below average yield and specific gravity, smaller vine type, dark russet skin, some deeper eyes
Silverton Russet (AC83064-6)	A76147-2 x A7875-5	0.3	Check variety, flat oblong type, attractive appearance, above average yield, higher percentage oversized tubers, larger vine type
Umatilla	Butte x A77268-4	0.4	Medium russet skin, variable type, average yield, higher proportion of pickouts, good internal quality, smaller vine type

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
Vanguard (TX08352-5RUS)	TXA549-1Ru x AOTX98137-1Ru	0.1	Very low specific gravity, average yield, good internal quality, common scab resistant, attractive tuber type
A06030-23	Premier Russet x A99113-6	0.1	Below average yield and specific gravity, moderate hollow heart, earlier vine maturity, attractive type
A08433-4STO	A02611-1 x AOND95249-1	0.2	Average yield and specific gravity, full season vine maturity, flat oblong type, lighter skin, nice appearance
A09119-4LB	A00472-20LB x Premier Russet	1.0	Average yield, above average specific gravity, common scab susceptible, non-uniform type, variable skin, larger vine type
A10071-1	Targhee Russet x AO02183-2	0.0	Average yield, moderate alligator hide, attractive skin, bellow average specific gravity, excellent internal quality, high proportion A-sized tubers
A10595-13sto	A96953-13sto x A0125-4	0.8	Average yield and specific gravity, light russet skin, earlier vine maturity, slight hollow heart
A11175-12TE	USDA ID	0.3	Oblong blocky type, attractive appearance, average yield, below average specific gravity, high proportion A-sized tubers
A11737-1LB	A96814-65LB x A05084-11	1.0	Smaller size profile, darker skin, below average yield and specific gravity, excellent internal quality

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
A12303-4sto	A96953-13sto x A06176-4	0.3	Long type, pointed ends, medium russet skin, above average yield and specific gravity
A12304-1sto	A96953-13sto x Clearwater Russet	0.4	Attractive appearance, oblong type, above average yield and specific gravity, moderate internal brown spot
A12327-5VR	A06862-11VR x La Belle Russet	0.2	Very high yield, many oversized tubers, below average specific gravity, nice appearance, moderate hollow heart and vascular discoloration
A13036-1	A08014-9TE x AO02183-2	0.5	Below average yield and specific gravity, variable tuber type, good internal quality, earlier vine maturity
A13085-2	A08069-3 x A061071-3CSR	0.2	Above average yield and specific gravity, tubular type, heavier skin, larger vine type, earlier vine maturity, higher proportion oversized tubers
A15008-2TE	A09001-14TE x A09004-2TE	0.1	Below average yield, very low specific gravity, attractive dark russet skin, very low specific gravity
AAF14025-2	AF3317-15 x PALB03035-7	0.8	Oval to oblong type, below average yield, smaller tuber size profile, very high specific gravity, full season vine maturity
AAF15010-1	AO9001-14TE x AF4116-9	0.8	Above average yield and specific gravity, high proportion A-sized tubers, full season vine maturity

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AAF15086-5	AF4320-7 x Mountain Gem Russet	1.3	Above average yield, high percentage A-sized tubers, good internal quality, more scab susceptible than average, full season maturity
AAF16069-1	AF5060-27 x Dakota Trailblazer	1.3	Oblong to long type, below average yield, smaller tuber size profile, below average specific gravity, moderate internal brown spot
AAF16069-2	AF5060-27 x Dakota Trailblazer	0.0	Attractive appearance, average yield, above average specific gravity, acceptable internal quality, common scab resistant
AF5707-1	A93575-4 x Dakota Trailblazer	1.2	Nice type and appearance, above average yield, slight hollow heart, larger vine type, flat oblong tuber type
AF5735-2	AF3317-15 x AF4342-3	1.2	Smaller tuber size profile, below average specific gravity, excellent internal quality, early vine maturity
AF5735-8	AF3317-15 x AF4342-3	1.2	Below average yield and specific gravity, flattened oblong to long type, above average common scab incidence
AF5762-8	AF4320-17 x Dakota Trailblazer	0.1	Nice dark russet skin, high percentage A-sized tubers, average yield, moderate internal brown spot
AF6298-2	A8469-5 x Gemstar Russet	0.8	Above average yield, earlier vine maturity, average specific gravity, flattened oblong tuber type

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AF6340-6	Caribou Russet x Russet Norkotah	0.8	Flattened blocky oblong tuber type, bellow average specific gravity, excellent internal quality, above average yield
AF6377-10	A03921-2 x Gemstar Russet	0.0	Nice russet skin, above average yield, larger tuber size profile, blocky oblong type, below average specific gravity
AF6377-13	A03921-2 x Gemstar Russet	0.0	Blocky type, above average yield, very high specific gravity, moderate hollow heart, common scab resistant
AF6465-7	AAF09014-2 x AF4296-3	0.1	Heavy russet skin, marginal appearance, below average yield, good internal quality, larger vine type, earlier vine maturity
AF6749-3	A96949-4 x Dakota Trailblazer	0.8	Moderate growth crack, average yield and specific gravity, higher proportion pickouts, smaller vine type
AF6750-3	Targhee Russet x AF5179-4	0.0	Blocky oblong type, below average specific gravity, good internal quality, above average yield
AF6814-1	AF4953-6 x Ranger Russet	1.0	Oblong to long type, above average yield and specific gravity, excellent internal quality, smaller vine type, full season vine maturity
AF6855-4	AF5071-2 x AF4296-3	0.5	Blocky oblong type, very high yield, slight hollow heart, nice appearance, fewer pickouts than average

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AOR07781-5	OA92A08-17 x PALB03035-6	0.0	Low yield and below average specific gravity, moderate vascular discoloration, very large vine type, earlier vine maturity
AOR10204-3	CCOA05110-3 x A05066-9	0.1	Average yield, below average specific gravity, moderate skinning, larger tuber size profile, common scab tolerance
AOR13064-2	A06029-4T x AO02183-2	0.2	Blocky oblong type, trace pointed tubers, above average yield and specific gravity, moderate hollow heart and vascular discoloration
ATTX10007-3RU	A02060-3TE x A05013-5TE	0.3	Very low yield, smaller tuber size profile, below average specific gravity, excellent internal quality, poor appearance
ATX15097-1RU	Castle Russet x A98345-1	0.5	Light russet skin, below average yield, above average specific gravity, full season maturity, slight hollow heart
ATX15120-1RU	Dakota Russet x A06084-1TE	0.0	Oblong type, below average yield, moderate hollow heart and internal brown spot, common scab resistance, larger vine type, earlier vine maturity
CO10085-1RU	CO03364-5RU x Silverton Russet	0.7	Attractive appearance, average yield, above average specific gravity, good internal quality, larger vine type
COA15494-8	CO10091-1RU x CO03276-5RU	0.0	Average yield, below average specific gravity, longer tuber type, moderate hollow heart and internal brown spot

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
COAF16277-4	CO11150-4RU x ORO5039-4	0.0	Average yield, oblong type, excellent internal quality, smaller vine type, larger tuber size profile
COTX08063-2RU	Premier Russet x A99073-1	0.8	Longer type, below average yield, very high specific gravity, excellent internal quality, large vine type
W13008-1Rus	University of Wisconsin	0.4	Above average yield, longer type, pointed tubers, very large vine type, average specific gravity, slight vascular discoloration
W13A11229-1RUS	A01325-1 x A06131-19	0.6	Flat oblong type, above average yield, high percentage A-sized tubers, very high specific gravity, moderate hollow heart
W17079-16rus	University of Wisconsin	0.4	Flat oblong type, heavy russet skin, high yield, moderate hollow heart, smaller vine type
W17081-2rus	University of Wisconsin	1.2	Light russet skin, common scab susceptible, high yield, severe internal brown spot, tubular type, higher percentage pickouts
W17091-12rus	University of Wisconsin	0.7	Smaller tuber type, below average specific gravity, good internal quality, common scab susceptible, full season maturity
W17094-3rus	University of Wisconsin	0.3	Poor type and appearance, high total yield but many pickouts, average specific gravity, excellent internal quality, very small vine type

2022 Russet Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
W17098-19rus	University of Wisconsin	0.7	High total yield but many pickouts, average specific gravity, excellent internal quality, tubular type, heavy russet skin, marginal appearance
W17098-43rus	University of Wisconsin	0.5	Variable russet skin, smaller tuber size profile, slight hollow heart, below average specific gravity
W17099-6rus	University of Wisconsin	1.3	Common scab susceptible, high proportion pickouts and B-sized tubers, excellent internal quality, tubular type
WAF17079-2	Payette Russet x AW07791-2RUS	0.0	Nice dark russet skin, above average yield, moderate hollow heart, excellent internal quality, smaller vine type, oblong flattened tuber type

* 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.

2022 Yellow Flesh Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
Acoustic	Meijer	1.5	Flat oval type, above average yield, lighter yellow flesh, second growth, sticky stolons, common scab susceptible
Alaska Gold	Solanum Int.	1.7	Very high yield, high percentage A-sized tubers, severe internal brown spot, pointed tubers, less waxy, lighter yellow flesh
Allora	Apart x Borwina	0.8	Oval to oblong type, good internal quality, netted skin, high percentage A-sized tubers
Ballerina	Parkland Seed Potatoes	0.5	Lower yield, smaller tuber size profile, very low specific gravity, excellent internal quality, large vine type, early vine maturity, waxier skin
Belmonda	Hanse Seed	0.0	Below average yield, excellent internal quality, very large vine type, full season vine maturity, lighter yellow flesh color
Bonafide (MSV093-1Y)	McBride x MSP408-14Y	0.4	High yield, high proportion A-sized tubers, slight vascular discoloration, vigorous vines, inconsistent tuber shape
Camelia	HZPC	1.3	Less uniform tuber type, high yield, dark yellow flesh, waxy skin, common scab susceptible
Christel	Norkia America	0.7	Flat oval tuber type, average yield, moderate vascular discoloration and internal brown spot, dark yellow flesh, less waxy skin, large vine type

2022 Yellow Flesh Varieties Cont.

Entry	Pedigree	2022 Scab Score*	Characteristics
Columba	Carerra x Agata	0.8	Above average yield, very low specific gravity, good internal quality, high proportion A-sized tubers, large vine type, lighter yellow skin
Constance	Marabel x AR93-1243	0.7	Average yield and specific gravity, flat oval type, attractive appearance, good internal quality
Danina	SunRain	1.4	Average yield and specific gravity, moderate vascular discoloration, waxy skin, dark yellow flesh, common scab susceptible
Erika	Marabel x AR 88-156	0.8	Low yield, smaller size profile, smooth waxy skin, oval to oblong type, good internal quality
Floridana	SunRain	1.7	Bright appearance, above average yield, slight vascular discoloration, trace heat knobs
Golden Globe (US 624-95)	Berber x 2.6 720-86	0.5	Above average yield, uniform oval type, moderate vascular discoloration, larger vine type, earlier vine maturity
Honey Ryder	SunRain	0.7	Attractive waxy skin, lower specific gravity, average yield, oblong type
Jelly	SunRain	0.6	Above average yield, high proportion A-sized tubers, slight vascular discoloration, full season vine maturity, sticky stolons, oval to oblong type

2022 Yellow Flesh Varieties Cont.

Entry	Pedigree	2022 Scab Score*	Characteristics
Mary Ann	Norkia America	1.1	Low yield, smaller tuber size profile, good internal quality, full season vine maturity, waxy skin, dark yellow flesh, a few pointed tubers
Montana	E 99/73/126 x E 99/89/130	1.2	Bright smooth skin, deep yellow flesh, good internal quality, common scab susceptible, below average yield
Natascha	Hanse Seed	1.8	Above average yield, average specific gravity, common scab susceptible, attractive bright skin, oblong tuber type
Paroli (24 205-06)	569 102-99 x 774 105-99	0.7	Above average yield, high proportion A-sized tubers, below average specific gravity, inconsistent type, large vine type
Queen Anne (05-043-1)	99-002-14 x Gala	0.7	Oval to oblong type, smooth waxy skin, good internal quality, below average yield, smaller tuber size profile
Sound	Meijer	1.2	Smaller tuber size profile, good internal quality, larger vine type, common scab susceptible
Tyson	HZPC	1.2	Bright round to oval type, trace pointed tubers, moderate vascular discoloration, lighter yellow flesh, average yield
Yukon Gold	Norgleam x W5279-4	1.8	Blocky round type, pink eyes, smaller vine type, high proportion A-sized tubers

2022 Yellow Flesh Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AF6194-4	University of Maine	0.5	Flat round type, below average yield, high proportion A-sized tubers, smaller vine type, earlier vine maturity, high specific gravity
AF6582-1	AF2376-5 x WAF10192-3	1.1	Flat oval type, lighter yellow flesh, larger vine type, good internal quality, average yield
AF6664-9	NY132 x AF5040-8	2.0	Uniform round tuber type, high proportion A-sized tubers, above average yield, severe vascular discoloration, common scab susceptible, large vine type
ATX052025-3W/Y	A00286-3Y x A99433-5Y	1.8	Flat uniform tuber type, average yield, common scab susceptible, above average specific gravity
CO09128-3 W/Y	Colorado State University	1.0	Very low yield, small tuber size profile, marginal appearance, good internal quality, smaller vine type
CO09128-5W/Y	Colorado State University	2.2	Uniform round type, smaller tuber size, high specific gravity, dark yellow flesh, larger vine type, earlier vine maturity
CO14226-3W/Y	Colorado State University	0.5	Very low yield, smaller tuber size profile, high specific gravity, good internal quality, very dark yellow flesh
MSBB343-2Y	MSQ341-8Y x MSL211-3	1.2	High yield, larger vine type, lighter yellow flesh, marginal appearance, blocky round to oval tubers

2022 Yellow Flesh Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
MSBB371-1Yspl	Michigan State University	0.0	High yield, purple splashes around eyes, higher specific gravity, good internal quality, larger vine type, rougher skin, lighter yellow flesh
MSZ615-2	Michigan State University	0.6	Deeper eyes, slight skinning, high yield, high proportion A-sized tubers, larger vine type, earlier vine maturity, lighter yellow flesh
TX17763-2Y/Y	ATTX00289-4W x NDTX05977s-1W	1.0	Low yield, smaller tuber size profile, very small vine type, flattened oblong to long type, smooth waxy skin
TX177975-11Y/Y	ATTX98500-3Pu/Y x CO07370-1W/Y	1.5	Inconsistent type, below average yield, very high specific gravity, moderate hollow heart, full season vine maturity
W13103-2Y	University of Wisconsin	0.8	High yield, good internal quality, light netted skin, blocky round type
W15234-5Y	University of Wisconsin	0.7	Below average yield, good internal quality, smaller vine type, very early vine maturity, very dark yellow flesh
W15240-2Y	NW64-6 x W9576-11Y	0.8	Above average yield, good internal quality, bright thin skin, oval to oblong type, some pointed tubers
W15248-17Y	University of Wisconsin	0.3	Below average yield, very low specific gravity, good internal quality, common scab tolerant

2022 Red Skin Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
Autumn Rose	Solanum	0.3	Below average yield, good internal quality, larger vine type, lighter red skin color
Colorado Rose	NDTX9-1068-11R x DT6063-1R	1.3	High yield, good internal quality, larger vine type, full season vine maturity, dark red skin color, slight skinning
Dark Red Norland	Redkote x ND626	0.1	Check variety for red potatoes, high yield, lower specific gravity, good internal quality, variable red skin color
Flamenco	HZPC	0.1	High yield, lower specific gravity, moderate vascular discoloration, poor appearance
Lollipop	Solanum	0.8	Very low yield, smaller tuber size profile, good internal quality, smaller vine type, earlier vine maturity
AAF11546-3	NDA050237B- x ND8555-8R	0.1	Above average yield, lower specific gravity, common scab tolerant, flat oval type, deeper eyes
AF6289-2	NY136 x Dark Red Norland	1.6	Sticky stolons, nice skin color, above average yield, good internal quality, common scab susceptible
AF6692-1	Nordonna x AF4831-2	2.0	High yield and specific gravity, good internal quality, common scab susceptible, blocky round to oval type
AF6693-1	Nordonna x AF4985-1	0.5	Below average yield, good internal quality, flat round to oval type, darker red skin

2022 Red Skin Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
AF6694-8	Nordonna x MSAFB607-5	0.0	Above average yield and specific gravity, larger vine type, full season vine maturity, uniform round to oval type
BNC559-1	NC313-3 x NY129	0.3	Above average yield, slight internal brown spot, smaller vine type, very dark red skin
BNC839-5	NC201-3 x Strawberry Paw	0.3	Average yield, high proportion A-sized tubers, good internal quality, smaller vine type, nice round shape
BNC917-2	BNC203-3 x Super Red Norland	1.0	High yield, severe vascular discoloration, moderate skinning, flat oval tuber type, earlier vine maturity
BTX2332-1R	Texas A&M University	0.5	Low yield, good internal quality, flat round type, unform red skin color
CO099076-6R	AC91848-1 x Rio Colorado	0.8	Uniform round type, slight skinning, high proportion A-sized tubers, good internal quality, larger vine type
CO14040-3R	CO99256-2R x CO05211-4R	0.0	Low yield, smaller tuber size profile, high specific gravity, good internal quality, smooth skin, round type
CO15084-4R	Colorado State University	0.0	Lower yield, high specific gravity, good internal quality, smaller vine type, very dark red skin
CO15113-1R	Colorado State University	0.4	Lower yield, round type, smaller vine type, mid-season vine maturity

2022 Red Skin Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
CO15115-2R	Colorado State University	0.3	Very low yield with few tubers, smaller size profile, small vine type and early vine maturity, trace growth crack
CO15211-5R	NDA050237B-1R x CO05228-4R	0.5	Low yield, round to oval type, moderate skinning, smaller vine type, good internal quality
COTX15111-1R	Colorado State University	0.5	Very low yield, small vine type, dark waxy red skin, good internal quality, variable skin color
MSCC553-1R	Michigan State University	0.3	Average yield, moderate vascular discoloration, larger vine type, darker red skin color, sticky stolons
NDA050237B-1R	ND028678-1RY x ND028770B-4R	0.6	High yield, lower specific gravity, moderate vascular discoloration, full season vine maturity, dark red skin color, slight skinning
NDA8512C-1R	USDA ID	0.3	Average yield, good internal quality, earlier vine maturity, flat round to oval type, poor appearance
NDAF113484B-1	ND060570B-1R x ND8555-8R	0.4	High yield, high proportion A-sized tubers, lower specific gravity, larger vine type, prominent eyes
NDAF12143-1	University of Maine	0.7	Above average yield, moderate vascular discoloration, less waxy skin, moderate skinning, some pointed tubers

2022 Red Skin Varieties Cont.

Entry	Pedigree	2022 Scab Rating*	Characteristics
NDAF12238Y-2	793101.3 x AND00272-1R	0.4	Blocky round type, high yield, good internal quality, larger vine type, lighter red skin, above average specific gravity
NDAF13296Y-4	ND081783-1R x 95043.11	0.9	High yield, high proportion A-sized tubers, good internal quality, attractive blocky round to oval type, slight sticky stolons
NDAF141Y-3	793101.3 x Dakota Ruby	0.5	High yield and specific gravity, full season vine maturity, deeper apical eyes, moderate skinning, good internal quality
NDTX12248Y-1R	95043.11 x Dakota Ruby	0.0	Low yield, good internal quality, smaller vine type, very early vine maturity, light red skin, poor appearance
W16025-5R	University of Wisconsin	1.0	Average yield, good internal quality, small uniform round tubers, light red skin, earlier vine maturity
W16030-4R	University of Wisconsin	0.7	Flat oval type, average yield, good internal quality, smaller vine type
W17005-3R	University of Wisconsin	0.0	Below average yield, moderate vascular discoloration, oval type
W17026-4R	University of Wisconsin	0.2	Below average yield, good internal quality, less waxy skin, trace growth crack
W17027-2R	University of Wisconsin	0.0	Below average yield, good internal quality, smaller vine type, variable shape

2022 Round White Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
Reba (NY 87)	Monona x Allegany	1.1	Check for round white varieties, average yield, high proportion A-sized tubers
Sifra	HZPC	0.8	Thin skin, bright appearance, high yield, full season vine maturity
Superior	USDA96-56 x M59.44	0.0	Check for round white varieties, larger vine type, oval to oblong tubers, deeper eyes
Volare	Parkland Seed Potatoes	1.2	Very high yield, lower specific gravity, bright appearance, light skin
AF5819-2	Dakota Crisp x AF4552-5	0.9	Above average yield, blocky round type, earlier vine maturity, recessed apical ends
AF5931-1	Eva x Lamoka	2.1	Lower yield, high proportion A-sized tubers, higher specific gravity, moderate vascular discoloration
AF6194-4	Waneta x AF4648-2	0.5	Lower yield, good internal quality, blocky round tuber type
AF6551-4	NDAF102629C-4 x MSR127-2	0.6	Higher yield, above average specific gravity, excellent internal quality, full season vine maturity
AF6735-2	B3054B-2 x AF5635-8	0.8	Below average yield, moderate vascular discoloration and internal brown spot
MSZ513-2	Michigan State University	0.3	Blocky round type, some pointed tubers, average yield, larger vine type

2022 Novelty Variety Descriptions

Entry	Pedigree	2022 Scab Rating*	Characteristics
Blackberry (MSV109-10PP)	COMN07-W112BGA x MSU200-5PP	0.3	Trace pointed tubers, chimeral white eyes on some tubers, high yield, good internal quality
BNC833-2	Purple Majesty x Adirondack Red	2.5	Non-uniform type, oblong tuber shape, heavier skin, common scab susceptible
MSZ109-8PP	COMN07-W112BGA x MSU200-5PP	0.5	Prominent deep eyes, high yield, larger vine, full season maturity, less unform skin color
Purple #10		0.0	Below average yield, full season vine maturity, less waxy skin, oval to oblong tuber type

* 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. 2022 Michigan Statewide Russet Potato Variety Trials
Overall Averages - Thirteen Locations

	CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
A12327-5VR[abcefgijm]	570	671	85	6	51	34	9	1.076	13	9	4	0	0.2	3.6	3.2	attractive russet skin, nice appearance, trace pointed tubers
AF6855-4[fl]	542	636	86	10	72	14	4	1.082	10	0	0	0	0.5	3.0	2.8	blocky oblong type, nice appearance
AF5707-1[abcefijm]	525	661	78	19	72	6	3	1.079	11	1	0	0	1.2	3.9	3.2	nice type and appearance, flat oblong type
AAF15086-5[el]	500	591	84	12	72	12	4	1.080	0	5	0	0	1.3	3.5	3.5	nice appearance, oblong, medium russet skin
W17079-16rus[km]	491	625	79	11	64	15	10	1.081	15	0	0	0	0.4	2.7	3.0	flat oblong type, heavy russet skin
AF6814-1[fl]	487	576	86	5	54	32	9	1.081	0	0	0	0	1.0	2.5	3.3	oblong to long type, medium netted skin
AF6377-10[cim]	486	526	92	4	56	36	4	1.072	7	3	1	0	0.0	3.3	2.7	blocky oblong type, nice russet skin
W17081-2rus[km]	485	697	70	9	63	7	21	1.075	0	0	35	0	1.2	3.6	2.8	light russet skin, tubular type
AAF15010-1[aekm]	474	586	79	17	69	10	4	1.094	13	0	0	0	0.8	3.6	3.4	variable type, heavy russet skin
W13A11229-1rus[abcdfgim]	473	595	79	17	74	5	4	1.085	17	5	0	0	0.6	3.3	3.0	flat oblong type, medium russet skin
Silverton Russet[abcefggimh]	**463**	**529**	**87**	**10**	**66**	**21**	**3**	**1.068**	**10**	**6**	**5**	**3**	**0.3**	**3.8**	**3.1**	**flat oblong type, nice appearance**
Reveille Russet[abcefggijmh]	460	518	88	7	62	26	5	1.067	0	6	1	0	0.1	2.8	3.1	uniform oblong type, moderate skinning, blocky
AF6750-3[fl]	455	586	78	11	63	15	11	1.070	5	0	0	0	0.0	2.8	3.3	blocky oblong type, acceptable appearance
AF6340-6[cim]	449	529	85	13	79	6	2	1.066	0	0	0	0	0.8	3.7	2.0	flattened blocky oblong type
A13085-2[abcfikm]	448	555	79	12	62	17	9	1.081	3	4	4	0	0.2	4.1	2.5	tubular type, heavier skin
W13008-1Rus[abcdfgim]	447	522	84	12	67	17	4	1.075	0	7	1	0	0.4	4.2	2.5	long type, pointed tubers, moderate alligator hide
AF6377-13[fikm]	441	553	81	12	66	15	7	1.087	17	0	3	0	0.0	3.3	3.0	blocky type, nice skin, trace growth crack
A12304-1sto[abcdfgikm]	440	586	73	24	67	6	3	1.082	1	4	19	1	0.4	3.4	3.1	nice appearance, oblong type, slight skinning
AOR13064-2[abefm]	439	536	82	12	64	18	6	1.084	23	12	5	0	0.2	4.5	2.9	blocky oblong type, dark skin, trace pointed tubers
A10071-1[am]	438	533	84	12	79	5	4	1.072	0	0	0	0	0.0	4.6	2.6	moderate alligator hide, nice skin
AF6298-2[bikm]	435	530	85	11	77	8	4	1.078	6	8	0	1	0.8	3.3	2.5	flattened oblong type
A08433-4sto[abcdfgijm]	434	546	78	17	66	12	5	1.075	6	6	1	0	0.2	3.1	3.5	flat oblong type, light russet skin, nice appearance
A12303-4sto[abcefggikm]	428	608	70	23	65	5	7	1.082	3	7	2	0	0.3	3.1	3.2	pointed ends, long type, medium russet skin
WAF17079-2[fl]	427	534	80	12	67	13	8	1.075	15	0	0	0	0.0	2.3	2.8	dark skin, nice appearance, flat oblong type
A11175-12TE[bcefim]	421	500	84	13	74	10	3	1.076	0	5	0	0	0.3	3.9	2.3	oblong blocky type, nice appearance
W17098-43rus[m]	418	734	57	28	56	1	15	1.073	10	0	0	0	0.5	3.5	3.0	tubular type, variable skin
W17099-6rus[km]	412	827	42	24	39	3	34	1.067	2	0	0	0	1.3	3.8	2.9	misshapen tubers, tubular type
COA15494-8[km]	408	524	77	15	73	4	8	1.068	15	0	15	0	0.0	2.8	2.4	**longer type, heavy russet skin**
A10595-13sto[m]	405	551	73	18	68	5	9	1.075	7	0	0	0	0.8	3.5	2.2	variable tuber type, light russet skin
Vanguard[abcefghim]	403	495	82	14	76	6	4	1.061	1	2	0	0	0.1	3.1	2.6	medium skin, nice shape, trace misshapen tubers
A09119-4LB[abcefim]	403	499	78	16	65	13	6	1.080	0	6	0	0	1.0	4.4	2.9	non uniform type, variable skin
AOR10204-3[abcefm]	399	519	76	9	53	23	15	1.068	9	3	2	1	0.1	3.8	2.6	moderate skinning, heavy russet skin
AF5762-8[abcfggikm]	394	494	81	13	73	8	6	1.084	12	5	16	0	0.1	3.1	3.1	nice dark russet skin, oblong type, deeper eyes
COAF16277-4[fl]	377	404	94	3	67	27	3	1.070	0	0	0	0	0.0	2.5	3.0	oblong type, medium russet skin
AAF16069-2[el]	373	498	76	18	72	4	6	1.084	10	0	15	5	0.0	3.0	3.0	nice appearance, trace growth crack, nice skin
AF5735-8[abcegi]	364	495	74	22	69	5	4	1.076	20	7	0	0	1.2	3.3	2.7	flattened oblong to long type, medium russet skin
AF6749-3[fl]	364	556	64	14	59	5	22	1.076	10	0	0	0	0.8	2.5	3.3	growth crack, marginal appearance
CO10085-1RU[abcefggijm]	357	507	69	20	61	8	11	1.083	0	2	3	0	0.7	3.7	3.1	nice appearance, medium russet skin
Ranger Russet[bfikm]	357	609	57	26	55	2	17	1.083	2	10	0	0	0.8	3.4	3.2	long tubular type, bottlenecks, deeper eyes
ATX15097-1RU[ae]	342	474	72	18	65	7	10	1.084	10	5	5	0	0.5	3.5	3.3	inconsistent type, light russet skin
W17094-3rus[km]	339	622	54	15	46	8	31	1.079	0	0	0	0	0.3	2.1	2.8	poor type and appearance
Umatilla[fgm]	339	632	53	21	50	3	26	1.081	0	0	0	0	0.4	2.3	2.7	medium russet skin, variable type
AF6465-7[im]	330	524	64	20	62	2	16	1.079	0	0	3	0	0.1	4.0	2.4	heavy russet skin, marginal appearance, deep eyes
W17098-19rus[km]	320	696	48	20	43	5	32	1.077	0	0	0	0	0.7	3.3	2.9	tubular type, heavy russet skin, marginal appearance
A11737-1LB[m]	311	503	61	29	61	0	10	1.071	0	0	0	0	1.0	2.5	2.3	smaller type, darker skin

LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	RAW TUBER QUALITY[3] (%)				COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
	US#1	TOTAL	US#1	Bs	As	OV	PO		HH	VD	IBS	BC				
AAF16069-1[el]	311	533	58	35	55	3	7	1.073	5	5	20	0	1.3	3.5	3.3	oblong to long, variable type, growth crack
Russet Norkotah[abcefgijm]	**304**	**448**	**64**	**26**	**55**	**9**	**10**	**1.072**	**10**	**2**	**0**	**0**	**0.2**	**2.8**	**2.9**	**darker russet skin, moderate pinkeye, deeper eyes**
Goldrush[abcefgim]	300	493	62	20	56	6	18	1.066	1	10	0	0	0.0	3.3	2.7	longer type, heavy skin
ATX15120-1RU[ae]	299	386	78	16	67	11	6	1.081	15	0	10	5	0.0	4.3	2.0	oblong type
AF5735-2[m]	293	590	50	43	49	1	7	1.072	0	0	0	0	1.2	3.2	2.0	flattened type, medium russet skin
A15008-2TE[abcfgmi]	291	394	73	24	67	6	3	1.065	7	3	10	0	0.1	3.7	2.6	nice dark russet skin, oblong type
A06030-23[abcfim]	290	350	84	11	74	10	5	1.073	17	5	0	0	0.1	3.1	2.2	nice oblong type, slight growth crack
AOR07781-5[ab]	289	382	71	19	64	7	10	1.073	5	10	0	0	0.0	5.0	2.3	misshapen tubers, trace pinkeye
AAF14025-2[aem]	279	502	55	34	50	5	11	1.092	0	0	8	0	0.8	3.8	3.9	flattened oval to oblong type, misshapen tubers
W17091-12rus[m]	276	563	48	34	45	3	18	1.064	3	0	0	3	0.7	3.7	3.3	moderate alligator hide, variable type
COTX08063-2RU[ak]	249	399	64	34	63	1	2	1.091	0	0	0	0	0.8	4.0	2.5	longer type, misshapen pickouts
A13036-1[abfgkmi]	243	369	63	26	59	4	11	1.072	0	7	0	0	0.5	3.1	2.6	variable tuber type, nice skin
ATTX10007-3RU[ai]	159	251	63	33	59	4	4	1.073	0	0	0	0	0.3	3.5	2.8	variable skin, poor appearance
Russet Burbank[fkm]	**107**	**550**	**21**	**32**	**21**	**0**	**47**	**1.068**	**0**	**0**	**0**	**0**	**0.1**	**3.2**	**2.9**	**long type, severely misshapen tubers**
MEAN	**386**	**537**	**72**	**18**	**62**	**10**	**10**	**1.076**	**6**	**3**	**3**	**0**	**0.5**	**3.4**	**2.8**	

2022 Russet Variety Trial Sites
[a]4-L Farm
[b]Horkey Farms
[c]Jenkins Farms
[d]Kitchen Farms, Mini Bulk Trial
[e]Kitchen Farmss, Strip Trial
[f]Lennard Ag. Co., Russet Trial
[g]Lennard Ag. Co., Russet Select Trial
[h]Sandyland Farms
[i]Styma Potato Farms
[j]Verbrigghe Farms
[k]Walther Farms, NFPT Trial
[l]Walther Farms, NFPT Add On Trial
[m]Walther Farms, Replicated Norkotah Trial

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

[2]SPECIFIC GRAVITY
Data not replicated

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

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

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

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

Table 10. 2022 Michigan Statewide Tablestock Potato Variety Trials
Overall Averages - Ten Locations

		CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							YELLOW FLESH		RED SKIN				
	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	WAXINESS[7]	FLESH COLOR[8]	WAXINESS[7]	SKIN COLOR[9]	UNIFORMITY[10]	SILVER SCURF[11]	COMMENTS
	MSBB343-2Y[abcefi]	534	585	91	5	87	4	4	1.074	2	12	2	3	1.2	4.4	2.9	2.8	2.4					blocky round to oval type, moderate growth cracks, poor appearance
	Alaska Gold[abccefi]	527	618	85	8	85	0	7	1.078	0	6	35	2	1.7	3.8	3.4	2.6	2.3					pointed tubers, light netted skin, variable type
	Columba[abcdfgi]	499	566	87	11	82	5	2	1.054	0	6	0	0	0.8	4.5	2.3	3.5	2.7					flat blocky round type, light skin
	Camelia[fi]	473	545	86	11	86	0	3	1.069	0	13	0	0	1.3	3.2	2.8	3.8	4.4					non uniform type, medium netted skin
	Paroli[abcefgi]	457	539	84	7	81	3	9	1.055	3	9	0	0	0.7	4.7	2.2	3.4	4.1					less uniform type, pointed tubers
	Bonafide[abfj]	455	511	89	7	87	2	4	1.067	0	10	0	0	0.4	4.0	3.3	3.1	3.0					inconsistent shape, medium netted skin
	Golden Globe[abcdfgi]	454	538	83	12	82	1	5	1.067	0	14	0	0	0.5	4.3	2.1	3.4	3.1					bright appearance, uniform round to oval type
	AF6664-9[b]	443	470	94	4	94	0	2	1.075	0	50	0	0	2.0	4.0	2.5	3.0	2.0					uniform round tuber type, medium netted skin
	MSZ615-2[abcefi]	443	481	91	8	91	0	1	1.067	2	6	2	0	0.6	4.6	2.2	3.4	2.6					deeper eyes, large round to oval type, slight skinning
	Allora[abcdfgi]	436	486	89	8	85	4	3	1.068	0	9	2	0	0.8	3.8	2.5	3.4	3.6					oval to oblong type, netted skin
	W13103-2Y[abcdfgi]	422	474	88	11	86	2	1	1.061	0	6	3	0	0.8	3.6	2.5	3.5	3.9					blocky round type, light netted skin
	Floridana[abcefi]	412	494	83	15	83	0	2	1.063	2	11	0	0	1.7	3.9	2.6	3.6	3.4					bright appearance, flat oval to oblong type, trace heat knobs
	W15240-2Y[abcefgi]	409	519	78	19	78	0	3	1.065	0	5	0	1	0.8	3.6	2.6	3.6	3.4					bright thin skin, oval to oblong type, pointed tubers
	MSBB371-1Yspl[ej]	408	517	79	21	79	0	0	1.078	0	0	0	0	0.0	4.5	3.0	2.0	1.5					purple splashed eyes, flat to round oval type
	Acoustic[abcdei]	392	510	74	21	74	0	5	1.054	0	13	0	0	1.5	4.3	2.7	3.4	2.7					flat oval type, sticky stolons, second growth
	Constance[abcdfgi]	388	476	81	16	78	3	3	1.064	0	2	0	0	0.7	3.9	2.7	3.3	3.3					flat oval type, nice appearance
	Jelly[abcefgi]	388	447	86	8	83	3	6	1.076	0	12	0	1	0.6	3.5	3.7	3.0	3.7					light netted skin, oval to oblong type, sticky stolons
	Natascha[abcdfi]	380	521	71	26	71	0	3	1.066	0	7	2	3	1.8	3.7	2.9	3.9	4.5					nice bright skin, pointed tubers, oblong type
	Yukon Gold[bgj]	**366**	**394**	**94**	**6**	**88**	**6**	**0**	**1.077**	**3**	**10**	**0**	**0**	**1.8**	**2.8**	**2.2**	**3.5**	**2.7**					**blocky round type, pink eyes**
YELLOW SKIN TYPE	Christel[abcdi]	363	490	72	23	72	0	5	1.058	2	15	14	4	0.7	4.1	2.9	2.9	4.4					flat oval tuber type, trace pointed tubers
	Honey Ryder[abcfi]	349	536	65	27	65	0	8	1.055	0	6	0	0	0.7	3.6	3.0	3.8	3.6					nice skin, oblong type, sticky stolons
	Danina[abcfi]	347	483	73	24	73	0	3	1.069	0	15	0	4	1.4	3.6	2.8	4.0	4.5					round to oval type, slight netted skin, pointed tubers
	ATX052025-3W/Y[ej]	341	452	74	23	74	0	3	1.074	0	10	0	0	1.8	3.0	3.0	2.8	2.3					flat uniform type, some pointed tubers
	AF6582-1[abcefi]	340	409	83	14	82	1	3	1.077	0	5	0	0	1.1	4.1	2.3	3.1	2.3					flat oval type, inconsistent skin
	Tyson[bcei]	340	412	80	14	80	0	6	1.066	0	19	0	0	1.2	3.5	2.3	3.1	2.5					bright round to oval type, trace points and knobs
	Belmonda[c]	316	384	82	16	82	0	2	1.062	0	0	0	0	0.0	5.0	3.5	2.5	2.0					poor appearance, flaky netted skin
	Montana[abcefi]	310	498	63	33	63	0	4	1.062	0	3	0	0	1.2	3.5	2.6	4.1	4.7					bright smooth skin, trace pointed tubers, nice appearance
	W15248-17Y[abcefi]	310	391	78	20	78	0	2	1.052	0	4	0	0	0.3	3.6	2.4	3.6	3.9					nice oval type, bright appearance, thin skin
	AF6194-4[j]	286	310	92	8	92	0	0	1.080	0	13	0	0	0.5	2.0	2.0	3.2	3.0					flat round type
	TX177975-11Y/Y[ej]	276	386	72	23	72	0	5	1.098	20	0	5	0	1.5	3.3	3.8	2.5	2.3					many pointed tubers, non-uniform type
	Queen Anne[abcefi]	274	439	62	33	62	0	5	1.060	0	3	0	0	0.7	3.3	2.8	4.2	4.6					nice smooth skin, waxy, oblong to long, bright
	Ballerina[abcefi]	270	406	67	28	67	0	5	1.055	0	2	0	0	0.5	4.4	1.8	3.7	3.4					flat oblong type, light netted skin
	Sound[abcdefi]	255	538	47	47	47	0	6	1.070	0	5	0	0	1.2	4.1	2.9	3.2	3.0					flat oval to oblong type, bright appearance, trace points
	W15234-5Y[i]	244	307	80	20	80	0	0	1.065	0	0	7	0	0.7	2.7	1.3	3.3	5.0					misshapen tubers, blocky round type
	Erika[abcdfgi]	192	404	44	51	44	0	5	1.063	0	5	0	0	0.8	3.3	2.4	3.8	3.8					smooth waxy skin, flat oval to oblong type, trace pointed tubers
	CO14226-3W/Y[i]	191	314	58	41	58	0	1	1.087	0	0	0	0	0.5	3.5	2.0	3.3	5.0					uniform small round type
	CO09128-5W/Y[befi]	172	349	50	50	50	0	0	1.078	0	8	1	0	2.2	4.3	2.0	3.1	4.5					small round uniform type, pink eyes
	Mary Anna[bcefi]	146	344	41	53	41	0	6	1.072	0	3	0	0	1.1	3.1	3.8	4.0	4.5					smooth bright skin, trace pointed tubers
	TX17763-2Y/Y[fj]	74	182	42	50	42	0	8	1.078	0	10	0	0	1.0	1.8	2.3	4.0	3.8					less uniform type, flattened oblong to long shape
	CO09128-3W/Y[abefi]	44	171	23	76	23	0	1	1.061	0	4	0	0	1.0	2.9	2.4	3.0	3.7					very small, thin skin, marginal appearance
	MEAN	343	448	74	22	73	1	4	1.068	1	8	2	0	1.0	3.7	2.6	3.3	3.4					

		CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							YELLOW FLESH		RED SKIN				
	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	WAXINESS[7]	FLESH COLOR[8]	WAXINESS[7]	SKIN COLOR[9]	UNIFORMITY[10]	SILVER SCURF[11]	COMMENTS
RED SKIN TYPE	NDAF113484B-1[abcdfgi]	431	473	92	5	90	2	3	1.061	0	10	0	0	0.4	4.0	2.5			2.9	4.1	4.1	0.9	uniform round to oval type, consistent skin color, prominent eyes
	Colorado Rose[ce]	417	508	80	18	80	0	2	1.071	0	5	0	0	1.3	3.8	3.3			3.8	4.5	3.8	1.0	flocky oval type, moderate growth crack, slight skinning
	NDA050237B-1R[abcefgi]	417	493	85	13	82	3	2	1.064	0	11	0	0	0.6	3.8	3.9			3.5	4.1	4.0	1.0	nice dark red skin color, flat round type, slight skinning
	CO099076-6R[abcdfgi]	399	432	91	7	88	3	2	1.075	0	6	0	0	0.8	3.7	2.6			2.9	3.9	3.2	1.0	uniform round type, slight skinning
	AAF11546-3[abi]	371	458	79	18	78	1	3	1.057	0	10	0	0	0.1	3.5	2.6			3.2	4.0	4.0	1.1	nice skin, deeper eyes, skinning, flat oval type
	AF6289-2[aci]	368	443	83	16	83	0	1	1.060	0	0	3	0	1.6	3.4	1.9			3.2	3.9	3.9	1.1	attractive skin color, sticky stolons, slight skinning
	NDAF12238Y-2[efi]	359	424	84	14	84	0	2	1.076	0	3	0	0	0.4	3.9	2.7			2.8	2.6	3.2	1.7	blocky round type, acceptable appearance
	AF6692-1[f]	353	384	92	6	92	0	2	1.079	0	0	0	0	2.0	3.0	3.5			3.5	4.0	4.0	1.0	moderate skinning, blocky round to oval type
	NDAF13296Y-4[efi]	351	379	92	7	92	0	1	1.076	0	7	0	0	0.9	3.2	2.6			3.0	3.4	4.1	1.8	nice blocky round to oval type, slight sticky stolons
	Dark Red Norland[abcefgi]	**348**	**408**	**85**	**12**	**85**	**0**	**3**	**1.059**	**0**	**4**	**0**	**0**	**0.1**	**3.8**	**1.7**			**3.3**	**3.3**	**2.5**	**1.8**	**prominent eyes, less uniform type, variable skin color**
	Flamenco[bi]	345	479	72	14	72	0	14	1.062	0	17	0	0	0.1	3.3	2.4			3.0	2.9	3.0	1.0	slight alligator hide, non-uniform type, poor appearance
	BNC917-2[i]	341	435	78	20	78	0	2	1.069	0	23	0	0	1.0	3.0	1.8			3.0	4.0	4.0	2.3	skinning, flat oval type
	NDAF141Y-3[efi]	333	455	73	25	73	0	2	1.085	0	1	0	0	0.5	3.2	3.5			2.8	3.1	3.2	1.4	deeper apical eyes, moderate skinning
	NDAF12143-1[abcdefgi]	311	377	83	14	74	9	3	1.069	0	9	0	1	0.7	3.0	2.8			2.9	3.5	3.4	1.1	round uniform type, moderate skinning, pointed tubers
	BNC559-1[i]	300	370	81	17	81	0	2	1.074	0	0	10	0	0.3	2.2	2.0			3.2	3.8	3.7	2.7	blocky oval type, dark red to almost purple skin
	MSCC553-1R[abcefi]	297	355	83	14	83	0	3	1.074	2	10	0	0	0.3	3.6	3.0			3.0	4.2	4.1	0.8	sticky stolons, moderate skinning, round type
	AF6694-8[f]	295	397	74	24	74	0	2	1.074	0	0	0	0	0.0	4.5	3.5			3.0	4.0	3.0	1.0	uniform round to oval type, netted skin
	W16030-4R[i]	286	357	80	19	80	0	1	1.069	0	0	0	0	0.7	2.0	1.5			3.0	3.8	3.7	1.0	flat oval type
	W16025-5R[i]	280	347	80	19	80	0	1	1.065	0	7	0	0	1.0	2.5	1.8			3.0	2.7	2.8	1.0	small uniform round tubers, light red skin
	CO15113-1R[fhij]	274	338	80	19	80	0	1	1.076	0	1	0	0	0.4	2.6	2.3			3.1	3.9	4.0	1.3	round type, acceptable appearance
	NDA8512C-1R[fij]	270	336	80	17	80	0	3	1.073	0	0	0	0	0.3	3.0	1.3			3.0	4.3	4.0	1.7	flat round to oval type, skin cracking, poor appearance
	BNC839-5[i]	252	277	91	7	91	0	2	1.073	0	0	0	0	0.3	1.5	2.0			3.3	4.0	3.7	1.0	attractive round shape, variable skin
	CO15084-4R[fj]	221	324	68	29	68	0	3	1.082	0	0	0	0	0.0	2.5	3.0			3.3	5.0	5.0	1.0	very dark skin, attractive type and appearance
	AF6693-1[fh]	217	286	76	20	76	0	4	1.070	0	0	0	0	0.5	2.8	2.3			3.3	4.0	4.0	1.0	deeper eyes, flat round to oval type
	Autumn Rose[abcei]	211	308	66	27	66	0	7	1.072	0	9	0	0	0.3	3.4	2.4			2.9	2.6	3.1	1.1	pointed tubers, moderate growth crack, inconsistent color
	W17005-3R[i]	173	285	61	34	61	0	5	1.067	0	17	0	0	0.0	2.7	2.0			3.2	3.3	3.0	1.0	oval type, misshapen tubers
	CO15211-5R[fij]	163	194	83	14	83	0	3	1.072	0	4	1	0	0.5	2.3	2.2			3.4	3.8	3.8	1.3	round to oval type, moderate skinning
	W17027-2R[i]	147	243	60	31	60	0	9	1.063	0	0	0	0	0.0	2.3	1.8			3.2	3.2	3.0	1.3	pointed tubers, variable shape, acceptable appearance
	W17026-4R[i]	141	241	57	43	57	0	0	1.062	0	0	0	0	0.2	2.7	2.2			2.8	3.8	3.3	1.0	trace growth crack, small round type
	BTX2332-1R[fj]	141	159	89	4	89	0	7	1.067	0	0	0	0	0.5	3.3	2.3			3.0	4.0	4.0	1.0	uniform flat round type
	CO14040-3R[fj]	120	228	50	50	50	0	0	1.080	0	0	0	0	0.0	3.5	2.3			3.5	3.3	3.5	1.0	nice appearance, smooth skin, round type
	NDTX12248Y-1R[j]	108	115	94	6	94	0	0	1.064	0	0	0	0	0.0	2.0	1.0			3.0	2.5	2.5	2.0	poor appearance
	Lollipop[fij]	57	186	30	70	30	0	0	1.071	0	0	0	0	0.8	2.3	1.8			2.9	2.8	2.8	1.0	small round to oval type
	COTX15111-1R[j]	23	45	51	43	51	0	6	1.068	0	0	0	0	0.5	1.5				4.0	4.0	3.5	1.0	variable skin color
	CO15115-2R[fj]	13	42	30	69	30	0	1	1.069	0	0	0	0	0.3	2.5	2.0			3.3	3.0	2.0	2.5	trace growth crack, small round type
	MEAN	261	331	75	22	75	1	3	1.070	0	4	0	0	0.5	3.0	2.4			3.1	3.6	3.5	1.3	
ROUND WHITE TYPE	Volare[abcfi]	614	689	88	10	88	0	2	1.056	4	10	2	0	1.2	3.9	2.3	3.2						round to oval type, bright appearance, light skin
	Sifra[cei]	580	690	82	16	82	0	2	1.073	0	8	0	0	0.8	3.8	3.2	2.3						thin skin, bright appearance, trace knobs
	AF6551-4[efi]	484	512	94	6	78	16	0	1.079	0	1	0	0	0.6	4.1	3.2	2.5						uniform blocky round type
	AF5819-2[abcefhi]	480	541	89	11	86	3	0	1.070	3	9	0	0	0.9	3.8	2.2	3.2						blocky round type, light netted skin, recessed apical ends
	Reba[abcef]	**467**	**490**	**95**	**4**	**94**	**1**	**1**	**1.070**	**0**	**10**	**0**	**4**	**1.1**	**3.8**	**3.2**	**3.1**						**netted skin, deeper eyes, blocky round type**
	MSZ513-2[abccefj]	435	482	90	8	87	3	2	1.064	2	5	7	0	0.3	4.6	2.3	3.2						flat blocky round to oval type, deep eyes, pointed tubers
	Superior[bcef]	**405**	**470**	**86**	**11**	**86**	**0**	**3**	**1.073**	**0**	**15**	**0**	**0**	**0.0**	**4.6**	**2.3**	**2.6**						**marginal appearance, oval to oblong type, deep eyes**
	AF6735-2[bh]	355	403	89	9	87	2	2	1.071	0	15	10	0	0.8	3.3	2.5	3.3						bright skin, nice appearance, round type
	AF5931-1[efi]	341	426	80	18	80	0	2	1.078	0	19	0	0	2.1	3.7	2.7	2.8						flat round to oval tuber type, bright appearance
	AF6194-4[ef]	329	363	91	8	91	0	1	1.076	0	5	0	0	0.5	4.0	3.3	2.8						blocky round type, medium netted skin
	MEAN	449	507	88	10	86	3	2	1.071	1	10	2	0	0.8	3.9	2.7	2.9						
NOVELTY TYPE	MSZ109-8PP[e]	548	604	91	8	91	0	1	1.070	0	0	0	0	0.5	4.0	4.0			1.0	5.0	1.0	3.0	chimeral white splash, prominent and deep eyes
	Blackberry[aeg]	**487**	**598**	**82**	**16**	**79**	**3**	**2**	**1.068**	**0**	**0**	**0**	**0**	**0.3**	**3.8**	**3.8**			**3.5**	**5.0**	**2.3**	**0.3**	**trace pointed tubers, white splashes on some tuber eyes**
	BNC833-2[e]	324	409	79	20	79	0	1	1.062	0	0	0	0	2.5	3.5	3.0			3.0	5.0	4.0	3.0	non-uniform tuber type, oblong, heavier skin
	Purple #10[e]	256	393	65	33	65	0	2	1.084	0	0	0	0	0.0	3.5	4.0			2.0	2.0	1.0	1.0	poor tuber shape, variable skin, oval to oblong type
	MEAN	404	501	79	19	79	1	2	1.071	0	0	0	0	0.8	3.7	3.7			2.4	4.3	2.1	1.8	
	TRIAL MEAN	**325**	**411**	**76**	**21**	**75**	**1**	**3**	**1.069**	**0**	**7**	**1**	**0**	**0.8**	**3.4**	**2.6**	**3.2**	**3.4**	**3.1**	**3.7**	**3.4**	**1.3**	

2022 Russet Variety Trial Sites
[a]4-L Farm
[b]Horkey Farms
[c]Jenkins Farms
[d]Kitchen Farms, Mini Bulk Trial
[e]Kitchen Farmss, Strip Trial
[f]Styma Potato Farms
[g]Verbrigghe Farms
[h]Walther Farms Early Generation Seletion
[i]Walther Farms Replicated Trial
[j]Walther Farms Strip Trial

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

[2]SPECIFIC GRAVITY
Data not replicated

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

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

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

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

[7]WAXINESS RATING
1: Heavy netting, buff
5: Waxy, smooth

[8]FLESH COLOR
1: White
5: Dark

[9]SKIN COLOR
1: Light pink
5: Dark red

[10]UNIFORMITY OF SKIN COLOR
1: Highly variable, non-uniform
5: Highly uniform, color throughout

[11]SILVER SCURF
0: No incidence of silver scurf
5: High incidence of silver scurf

Table 11. 2022 Russet Potato Variety Trial
Walther Farms NFPT and Added Lines

Planting: 4/29/22 Vine Kill: 8/31/22 Harvest: 9/28/22

GDD_{40}: 3573

LINE	CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
A15053-17	669	821	82	9	70	12	9	1.068	0	0	0	0	0.5	3.0	2.5	light russet skin, knobs, alligator hide, flat tubular type
A10861-3CR	611	700	87	8	74	14	4	1.077	10	0	40	0	1.5	3.0	2.5	variable skin color, misshapen pickouts
AAF15010-1	611	739	83	23	70	1	6	1.100	0	0	0	0	1.0	3.0	3.0	moderate alligator hide, less uniform type
A12303-4sto	593	744	80	26	70	3	1	1.081	0	0	0	0	0.0	2.5	2.5	heavy russet skin, flat oblong pointed type
A12305-2adg	589	779	76	5	61	15	19	1.072	0	0	0	0	0.5	3.0	2.5	long tubular type, points, slight alligator hide, growth cracks
AF5736-16	571	597	96	3	86	10	1	1.092	0	0	0	20	0.0	2.5	3.0	silverton type, flat blocky oblong, nice
A15041-13	555	602	92	4	50	42	4	1.071	10	0	0	0	0.5	2.5	2.5	oblong blocky type, deeper eyes, acceptable appearance
W17079-16rus	543	667	81	11	61	19	9	1.079	30	0	0	0	0.5	2.5	3.0	flat oblong tuber type, heavy russet skin
W17081-2rus	538	754	71	9	67	6	18	1.077	0	0	40	0	1.5	3.5	3.0	light russet, tubular, bottlenecking
ND1412Y-5Russ	534	630	85	7	71	14	8	1.085	0	0	0	0	1.0	3.0	3.0	points, medium russet skin
AF6377-12	528	611	86	10	68	19	3	1.078	10	0	0	0	0.5	2.5	2.5	slight alligator hide, apical growth cracks, dark russet skin
A15102-11	517	650	80	14	72	7	7	1.084	0	0	50	0	1.0	3.0	2.5	moderate silver scurf, light russet, tubular
A13085-2	511	606	84	15	59	9	17	1.073	0	0	0	0	0.5	2.5	2.0	acceptable appearance, medium russet skin, tubular
A13036-1	504	648	78	29	65	0	6	1.080	0	0	0	0	0.0	3.5	2.5	nice skin, heat sprouts, misshapen pickouts, prominent eyes
A15094-11	499	820	61	21	59	2	18	1.067	0	0	0	0	1.0	3.5	3.0	misshapen, growth cracks, light variable skin, poor appearance
AF6441-3	499	599	83	10	74	9	7	1.071	0	0	0	0	0.5	3.5	3.0	apical sprouting, dark russet skin, flat long type, poor appearance
A15094-13	490	711	69	11	66	3	20	1.065	0	0	0	0	0.0	3.0	3.0	very tubular type, bottlenecking, growth cracks, light russet skin
W17099-6rus	488	911	54	29	32	1	38	1.065	0	0	0	0	1.5	3.5	3.0	very tubular type, misshapen, poor appearance
A12304-1sto	476	654	73	32	57	1	10	1.079	0	0	20	0	0.5	3.0	2.5	flattened tubular type, growth cracks in pickouts, good appearance
AF6314-12	475	563	84	11	64	20	5	1.077	10	0	40	0	0.0	3.0	2.5	variable skin, moderate alligator hide, marginal appearance
A15057-2TE	466	528	88	12	79	9	0	1.068	0	0	0	0	0.0	3.0	3.0	flat blocky oblong type, very nice appearance
A09136-9LB	460	556	83	12	56	27	5	1.089	0	0	0	0	0.0	3.0	2.5	flat oblong type, silverton type, medium netted skin, good appearance
A11887-5adg	440	599	73	13	69	5	13	1.064	0	0	0	0	1.5	3.0	2.5	variable tubular tuber type, bottlenecking, poor appearance
A16117-4	430	570	75	7	46	29	18	1.080	0	0	0	20	1.5	3.5	3.0	tubular, growth crack, marginal appearance
A13074-1TE	426	607	70	15	63	7	15	1.083	0	0	0	0	0.0	3.0	2.0	nice skin, poor type, apical growth cracks and allligator hide
A15175-1	423	697	61	20	60	1	19	1.077	0	0	0	0	0.5	3.0	2.5	tubular type, bottlenecking, light variable russet skin
A13038-3	421	560	75	10	70	5	15	1.071	0	0	0	0	0.5	1.5	3.0	very tubular type, too many eyes
AF6377-13	411	568	72	13	74	3	10	1.080	10	0	0	0	0.0	2.5	3.0	heavy russet, less uniform type, apical alligator hide and growth crack
A16051-3	404	573	70	15	64	7	14	1.063	0	0	0	0	1.0	3.0	3.0	light russet skin, growth cracks, alligator hide, bottlenecking
A15082-9	398	511	78	13	74	3	10	1.072	0	0	0	0	0.5	3.5	2.0	moderate silver scurf, misshapen tubers, tubular type
AF5521-1	394	473	83	14	74	10	2	1.085	0	0	30	0	0.5	2.5	3.0	good appearance
AF6298-2	390	530	74	16	73	10	1	1.076	10	0	0	0	0.5	3.0	2.5	non uniform type, pointed tubers
A12327-5	389	703	55	8	41	14	37	1.076	0	0	0	0	0.0	3.5	2.5	medium to heavy netted skin, growth crack, bottlenecks,
A16088-1	384	435	88	8	71	17	4	1.063	0	0	0	0	0.5	2.5	2.0	moderate alligator hide, nice skin, flat oblong type
AF6384-2	381	534	71	17	54	18	11	1.063	40	0	0	0	0.5	3.0	3.0	variable type, slight alligator hide, growth cracks
COA15494-8	376	453	83	15	72	3	10	1.067	30	0	10	0	0.0	2.5	2.5	alligator hide, heavy russet skin, elongated type
CO13003-1RU	370	491	75	21	71	5	3	1.070	20	0	0	20	0.0	3.0	2.5	oblong tuber type, medium russet skin, good appearance
W17094-3rus	365	657	56	16	44	7	33	1.080	0	0	0	0	0.0	1.5	2.5	very poor type and appearance
Ranger Russet	362	620	58	34	51	0	15	1.083	10	0	0	0	1.0	2.5	3.0	tubular, bottlenecks, light skin
AF6434-1	361	637	57	8	54	3	35	1.070	0	0	0	0	1.0	2.5	2.5	knobs, misshapen, uneven light russet skin, tubular
AFA5661-8	359	514	70	19	68	2	11	1.076	0	0	0	0	0.5	2.5	3.0	light russet skin, apical growth cracks, alligator hide
NDAF13242B-3	358	558	64	34	64	0	2	1.078	0	0	0	0	1.5	2.5	3.0	tubular type, light russet skin
W17098-19rus	357	735	49	19	46	8	27	1.076	0	0	0	0	1.0	3.0	3.0	very tubular type, poor appearance, growth cracks, alligator hide

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]	VINE VIGOR[5]	VINE MATURITY[6]	COMMENTS
A15258-1	351	542	65	14	60	5	21	1.062	0	0	0	0	0.5	2.5	3.0	long tubular type, light russet skin, bottlenecking
ND1413YB-1Russ	350	434	81	10	58	23	9	1.078	80	0	0	0	1.0	3.0	3.0	oblong tubular type, light to medium russet skin
A15254-5	338	662	51	11	46	5	38	1.075	0	0	20	0	0.5	3.0	2.5	tubular, misshapen, medium russet skin
A15399-2LB	335	755	44	24	44	0	32	1.074	0	0	0	0	1.0	3.0	3.0	growth cracks, heat sprouts, points, misshapen tubers
A15121-2TE	329	542	61	17	61	0	22	1.092	0	0	0	0	0.0	3.0	2.5	heavy russet skin, tubular, not uniform, bottlenecking, growth cracks
A15190-8CR	321	653	49	22	47	2	29	1.070	0	0	0	0	0.0	3.0	2.5	tubular, bottlenecks, light skin
A16137-6sto	296	429	69	28	68	1	3	1.065	0	0	0	0	1.0	2.5	3.0	oblong tuber type, light russet skin, trace of alligator hide
AF6338-6	277	655	42	22	38	4	36	1.056	0	0	0	0	0.0	3.0	2.5	very tubular type, bottlenecking, growth cracks
AAF10596-1	277	495	56	29	52	4	15	1.078	0	0	0	0	0.5	3.0	3.0	variable russet skin and type, silver scurf
COTX08063-2Ru	264	463	57	43	57	0	0	1.089	0	0	0	0	1.0	3.5	2.5	moderate alligator hide, long tubular type, medium russet skin
AF5762-8	235	376	62	17	75	5	3	1.069	0	0	20	0	0.5	2.5	3.0	flat blocky oblong type, medium russet skin, deeper eyes
AC12090-3RU	229	433	53	31	52	1	16	1.061	0	0	0	0	0.0	2.5	2.5	not uniform tubular type, heavy russet skin, pink blush on skin
A15051-1T	221	616	36	29	34	2	35	1.074	0	0	0	0	0.0	3.0	3.0	very tubular, bottlenecks, misshapen tubers
A16048-3	168	408	41	23	38	3	36	1.060	0	0	0	0	0.5	3.0	3.0	tubular, rough, alligator hide, light skin
Russet Burbank	**77**	**471**	**16**	**37**	**24**	**0**	**39**	**1.067**	**0**	**0**	**0**	**0**	**0.0**	**2.5**	**3.0**	**long tubular type, severe bottle necking**
AAF15086-5	602	712	85	11	69	16	4	1.077	0	0	0	0	1.0	2.5	2.5	blocky oblong tuber type, medium russet skin, good appearance
AF6855-4	540	653	83	12	76	7	5	1.081	0	0	0	0	1.0	3.0	2.5	nice appearance, blocky oblong type
AF6814-1	455	533	85	5	69	17	9	1.081	0	0	0	0	1.0	2.5	3.0	flat oblong to long type, medium netted skin, pointed tubers
AF6750-3	421	538	78	8	60	18	14	1.065	10	0	0	0	0.0	2.5	3.0	blocky oblong to long type, pointed tubers, acceptable appearance
WAF17079-2	366	485	75	15	73	3	9	1.072	0	0	0	0	0.0	2.0	2.5	dark russet skin, nice appearance, flat oblong type
AAF16069-2	363	544	67	22	65	2	11	1.080	0	0	30	10	0.0	2.0	2.5	good appearance, tubular, trace growth crack and alligator hide
COAF16277-4	328	356	92	3	75	17	5	1.069	0	0	0	0	0.0	2.5	3.0	blocky oblong type, medium netted skin, trace growth crack
AAF16069-1	323	576	56	32	50	6	12	1.065	0	0	40	0	0.5	2.5	3.0	not uniform, tubular, growth cracks
AF6749-3	249	500	50	19	48	2	31	1.073	0	0	0	0	1.0	2.0	3.0	growth crack, alligator hide, rough tubular appearance
A10611-3adg	192	529	36	26	36	0	38	1.077	0	0	0	0	0.5	2.0	2.5	growth crack, tubular, less uniform, bottlenecks
MEAN	**409**	**592**	**69**	**17**	**60**	**8**	**15**	**1.074**	**4**	**0**	**5**	**1**	**0.5**		**2.7**	

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

[2]**SPECIFIC GRAVITY**
Data not replicated

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

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

FIELD DATA

Planting Date	4/29/22
Vine Kill Date	8/31/22
Harvest Date	9/28/22
Days (planting to vine kill)	124
Days (planting to harvest)	152
GDD_{40} MAWN Station	Mendon
GDD_{40} (planting to vine kill)	3573
Seed Spacing	10"

[5]**VINE VIGOR RATING**
Date: 6/10/22
Rating 1-5
1: Slow emergence
5: Early emergence (vigorous vine, some flowering)

[6]**VINE MATURITY RATING**
Date: 8/18/22
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

Varieties below the dashed line are added lines

Table 12. 2022 Tablestock Potato Variety Trial

Walther Farms Cass City

Planting: 5/13/22 Vine Kill: 9/6/22 Harvest: 10/5/22

GDD[40]: 3342

		CWT/A		PERCENT OF TOTAL[1]						RAW TUBER QUALITY[3] (%)							YELLOW FLESH		RED SKIN				
	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	HH	VD	IBS	BC	COMMON SCAB RATING[4]	VINE VIGOR[5]	VINE MATURITY[6]	WAXINESS[7]	FLESH COLOR[8]	WAXINESS[7]	SKIN COLOR[9]	UNIFORMITY[10]	SILVER SCURF[11]	COMMENTS
YELLOW SKIN TYPE	MSII323-07	613	688	89	10	70	19	1	1.067	0	0	0	0	1.5	2.0	2.0	3.0	4.0					very large tubers
	MSII346-02	453	577	79	21	79	0	0	1.078	0	0	0	0	1.0	3.0	1.5	3.5	3.5					good yield, some recessed apical eyes, slight netting
	MSII323-06	441	516	85	14	85	0	1	1.061	0	0	0	0	1.5	2.5	2.0	3.0	4.0					bright, round, some deep eyes
	MSII320-04	366	402	92	6	89	3	2	1.057	0	0	0	0	2.5	2.0	2.5	3.0	3.0					good size, round, uniform, slight netting
	MSII319-02	316	386	82	16	82	0	2	1.066	0	0	0	0	0.5	2.0	1.5	4.0	3.0					very bright, smooth, oval
	MSII309-03	301	396	76	23	76	0	1	1.083	0	0	0	0	0.5	2.5	2.5	3.0	4.0					round, uniform, light netting
	MSII344-05	290	396	73	25	73	0	2	1.075	0	0	0	0	0.5	2.5	1.5	3.0	4.0					oval type, some skinning
	MSII309-08	261	312	84	16	84	0	0	1.079	0	10	0	0	0.5	1.5	2.0	3.0	3.0					round, uniform, light netted skin
	MSII320-03	249	314	79	19	79	0	2	1.069	0	0	0	0	2.0	2.5	2.5	3.0	4.0					round, uniform, flat, netted
	MSII309-06	245	315	78	20	78	0	2	1.080	0	0	0	0	1.0	2.0	1.5	3.0	3.0					uniform, smooth, some alligator hide
	WAF13058-1	242	288	84	14	84	0	2	1.071	0	0	0	0	1.0	3.0	1.5	3.0	3.0					blocky, round, light netted skin, good size
	MSII323-04	242	279	87	10	87	0	3	1.062	0	0	0	0	1.0	1.5	2.0	3.5	3.0					smooth, round, some pointed tubers
	MSII308-05	240	348	69	31	69	0	0	1.067	0	0	0	0	1.0	2.5	2.0	3.5	3.0					uniform, round, light netting, medium size
	MSII306-08	218	307	71	29	71	0	0	1.070	0	0	0	0	2.0	2.0	2.5	3.0	3.0					round type, bright skin
	MSII344-02	216	308	70	28	70	0	2	1.075	0	0	0	0	1.0	2.0	2.0	4.0	4.0					very bright, smooth skin, oval type
	MSII306-04	207	313	66	34	66	0	0	1.062	0	0	0	0	1.0	2.5	1.5	3.0	3.0					round to oval type, prominent lenticels
	MSII330-03	172	227	76	22	76	0	2	1.071	0	0	0	0	1.5	2.0	2.0	3.5	3.0					bright, some netting, pink eyes, variable type
	MSII306-06	139	235	59	41	59	0	0	1.066	0	0	0	0	1.0	1.0	2.0	3.5	3.0					small tuber size
	NYT61-2	137	250	55	45	55	0	0	1.077	0	0	0	0	1.0	2.0	2.0	3.5	3.5					smooth, oval type, pink eyes
	NYT61-3	129	169	76	16	76	0	8	1.079	0	0	0	0	0.5	0.0	2.0	3.5	4.0					smooth, oval type, growth crack, pointed tubers
	MSII328-3	119	121	98	2	98	0	0	1.076	0	0	0	0	1.0	1.5	1.0	3.5	3.0					bright, round type
	MSII311-02	106	235	45	54	45	0	1	1.080	0	0	0	0	1.0	2.0	1.5	3.0	3.5					Small, oval, light netting
	MSII344-06	83	249	33	67	33	0	0	1.076	0	0	0	0	0.5	2.5	1.5	3.5	4.0					uniform, round, small, some netting
	MEAN	**252**	**332**	**74**	**24**	**73**	**1**	**1**	**1.072**	**0**	**0**	**0**	**0**	**1.1**	**2.0**	**1.9**	**3.3**	**3.4**					
RED SKIN TYPE	CO15113-1R	359	415	86	13	86	0	1	1.072	0	0	0	0	1.0	2.5	2.5			3.5	3.5	4.0	1.5	round type, acceptable appearance
	MSII418-12	336	392	86	12	86	0	2	1.073	0	0	0	0	0.5	2.0	1.5			3.5	4.0	4.0	1.0	uniform, round, good color, some netting
	MSII415-01	261	314	83	16	83	0	1	1.076	0	0	0	0	1.0	2.0	2.0			3.0	4.0	4.0	1.0	uniform, distinct red skin hue
	MSII417-02	251	326	77	23	77	0	0	1.067	0	0	0	0	0.5	3.0	1.5			3.0	3.0	4.0	1.0	round, uniform, bright, lighter red skin
	COTX15083-1R	248	296	84	14	84	0	2	1.071	0	0	0	0	1.5	1.5	2.5			3.0	4.0	4.0	1.0	round, uniform, good color, some netting
	MSII425-01	246	286	86	14	86	0	0	1.061	0	0	0	0	0.5	2.5	1.0			3.5	3.5	4.0	1.0	good shape, good color, slightly deep eyes
	MSII419-05	218	263	83	12	83	0	5	1.067	0	0	0	0	0.5	1.5	2.0			3.5	4.0	4.0	1.0	nice, bright, smooth, unique red to purple skin color
	AF6693-1	186	238	78	19	78	0	3	1.068	0	0	0	0	1.0	2.0	1.0			3.5	4.0	4.0	1.0	acceptable color, marginal appearance, deeper eyes
	ND14220B-9R	184	266	69	31	69	0	0	1.064	0	0	0	0	0.5	2.0	1.5			3.5	3.5	4.0	1.5	round, smooth, bright, heavy lenticels
	ND14325B-7R	157	238	66	32	66	0	2	1.071	0	0	0	0	0.5	2.0	1.5			3.5	4.0	4.0	1.0	good color, small, round, uniform
	ND14324B-7R	144	208	69	31	69	0	0	1.076	0	0	0	0	0.5	1.0	1.5			3.5	4.0	4.0	1.0	uniform, round, good color, darker eyes, small
	TX17802-5R	139	198	70	27	70	0	3	1.071	0	0	0	0	1.5	2.5	1.5			3.0	4.0	4.0	1.0	good color, some recessed apical eyes, variable size
	MSII419-03	129	193	67	24	67	0	9	1.066	0	0	0	0	0.5	2.0	1.0			3.0	3.5	3.5	1.0	smooth, round, light red skin
	MSII432-01	126	196	64	35	64	0	1	1.061	0	0	0	0	0.0	2.0	1.0			4.0	4.0	4.0	1.0	nice, round, bright, smooth
	MSII421-10	115	161	72	17	72	0	11	1.051	0	0	0	0	0.0	1.5	1.0			3.0	4.0	4.0	2.0	smooth, round to oval type, good color, some growth crack
	MSII432-03	65	164	40	60	40	0	0	1.055	0	0	0	0	0.5	2.0	1.0			3.5	4.0	3.5	1.0	smooth, very small tubers
	MSII421-05	40	98	41	57	41	0	2	1.057	0	0	0	0	0.5	1.5	1.5			3.5	4.0	4.0	1.0	bright round, uniform, very small tubers
	MEAN	**189**	**250**	**72**	**26**	**72**	**0**	**2**	**1.066**	**0**	**0**	**0**	**0**	**0.6**	**2.0**	**1.5**			**3.4**	**3.8**	**3.9**	**1.1**	
ROUND WHITE TYPE	AF6735-2	302	341	89	10	85	4	1	1.079	0	0	0	0	1.5	2.5	2.5	3.5						large, round, recessed apical eyes, bright, slight netted skin
	AF5819-2	299	331	90	10	90	0	0	1.071	0	0	0	0	0.5	2.0	2.5	3.0						round, recessed apical ends
	AF6541-3	252	305	83	17	83	0	0	1.075	0	0	0	0	1.0	2.5	1.5	3.5						flat, round, fairly uniform
		284	**326**	**87**	**12**	**86**	**1**	**0**	**1.075**	**0**	**0**	**0**	**0**	**1.0**	**2.3**	**2.2**	**3.3**						
	TRIAL MEAN	**229**	**299**	**74**	**24**	**74**	**1**	**2**	**1.070**	**0**	**0**	**0**	**0**	**0.9**	**2.0**	**1.7**	**3.3**	**3.4**	**3.4**	**3.8**	**3.9**	**1.1**	

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

[2]SPECIFIC GRAVITY
Data not replicated

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

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

[5]VINE VIGOR RATING
Date: 6/14/22
Rating 1-5
1: Slow emergence
5: Early emergence

[6]VINE MATURITY RATING
Date: 8/17/22
Rating 1-5
1: Early (vines completely dead)
5: Late (vigorous vines, some flowering)

FIELD DATA

Planting Date	5/13/22
Vine Kill Date	9/6/22
Harvest Date	10/5/22
Days (planting to vine kill)	116
Days (planting to harvest)	145
GDD_{40} MAWN Station	Fairgrove
GDD_{40} (planting to vine kill)	3342
Seed Spacing	10"

[7]WAXINESS RATING
1: Heavy netting, buff
5: Waxy, smooth

[8]FLESH COLOR
1: White
5: Dark yellow

[9]SKIN COLOR
1: Light pink
5: Dark red

[10]UNIFORMITY OF SKIN COLOR
1: Highly variable, non-uniform
5: Highly uniform, color throughout

[11]SILVER SCURF
0: No incidence of silver scurf
5: High incidence of silver scurf

Evaluating New Potato Varieties for Herbicide Sensitivity-2022 MPIC Research Report

Erin Burns, Assistant Professor-Weed Science Extension Specialist
Department of Plant, Soil, and Microbial Sciences, Michigan State University

The potato research team at MSU is continually striving to introduce new potato varieties that have improved agronomic, storability, and processing qualities compared to standard commercial varieties. In recent years, varieties like Silverton Russet have been introduced to the US commercial potato industry with susceptibility to commonly used broadleaf herbicides. In the commercialization process, many growers have experienced yield losses, and therefore significant economic loss, which results in slow variety adoption or even rejection. Many times the developer of new varieties is not aware of all potential weaknesses of a variety and is unable to warn growers of potential management concerns like herbicide sensitivities. To protect the commercial potato industry in Michigan from these unforeseen impacts, the Michigan State University Weed Science and Potato Outreach Programs propose that all potato varieties nearing commercialization be screened for sensitivity to commonly used herbicide treatments. Therefore, objective one of this research was to identify varietal sensitivity to commercially used herbicides prior to release. The following list of advanced chip and russets varieties are nearing commercialization in Michigan: Lady Liberty, Mackinaw, Petoskey, Reveille, and Vanguard. These varieties were compared to the check varieties Atlantic, Lamoka, Snowden, Russet Norkotah, and Russet Silverton.

This study was conducted at the Montcalm Research Center. Four replicate blocks were included in the study consisting of the following advanced chip and russet varieties that are nearing commercialization in Michigan: Lady Liberty, Mackinaw, Petoskey, Reveille, and Vanguard. These varieties will be compared to the check varieties Atlantic, Lamoka, Snowden, Russet Norkotah, and Russet Silverton. The study was planted on 5/25/22. To isolate the impact of herbicide injury on yield and keep a weed free environment a blanket preemergence herbicide application of s-metolachlor plus linuron (trade names Dual/Brawl and Lorox/Linex) was made to control grass and broadleaf weeds. To evaluate injury resulting from postemergence herbicide application rimsulfuron (1 oz/A, trade name Matrix) with and without metribuzin (0.25 lb/A) were applied on 6/23/22.


Figure 1. Variety sensitivity trial 2022

Plot design followed that utilized in the Potato Outreach Program's on-farm variety trials (Figure 1). Herbicide treatments were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 187 L ha^{-1} at a pressure of 207 kPa through 11003 AIXR flat-fan nozzles. Percent weed control (0% = no control, 100% = complete control) and potato injury (0% = no injury, 100% = complete injury) were evaluated 7, 14, and 21 days after herbicide application and at harvest. The study was harvested 9/21/22. Yield data are presented in Figures 2-4.

Overall, potato varieties varied in their sensitivity to postemergence herbicides. The Michigan Potato Industry Commission supported this research.

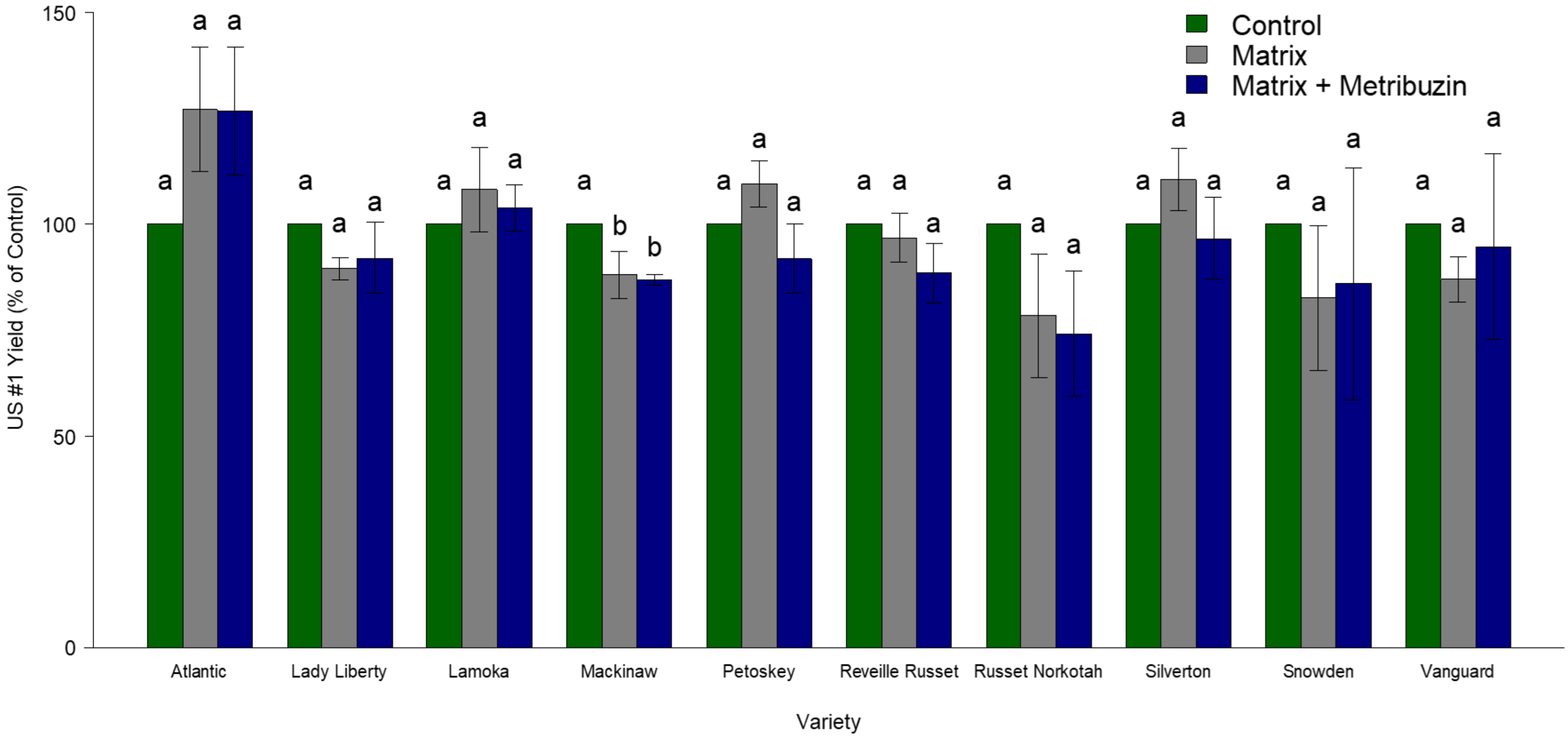


Figure 2. US #1 Yield (% of Control) for variety sensitivity 2022 trial at the Montcalm Research Center.

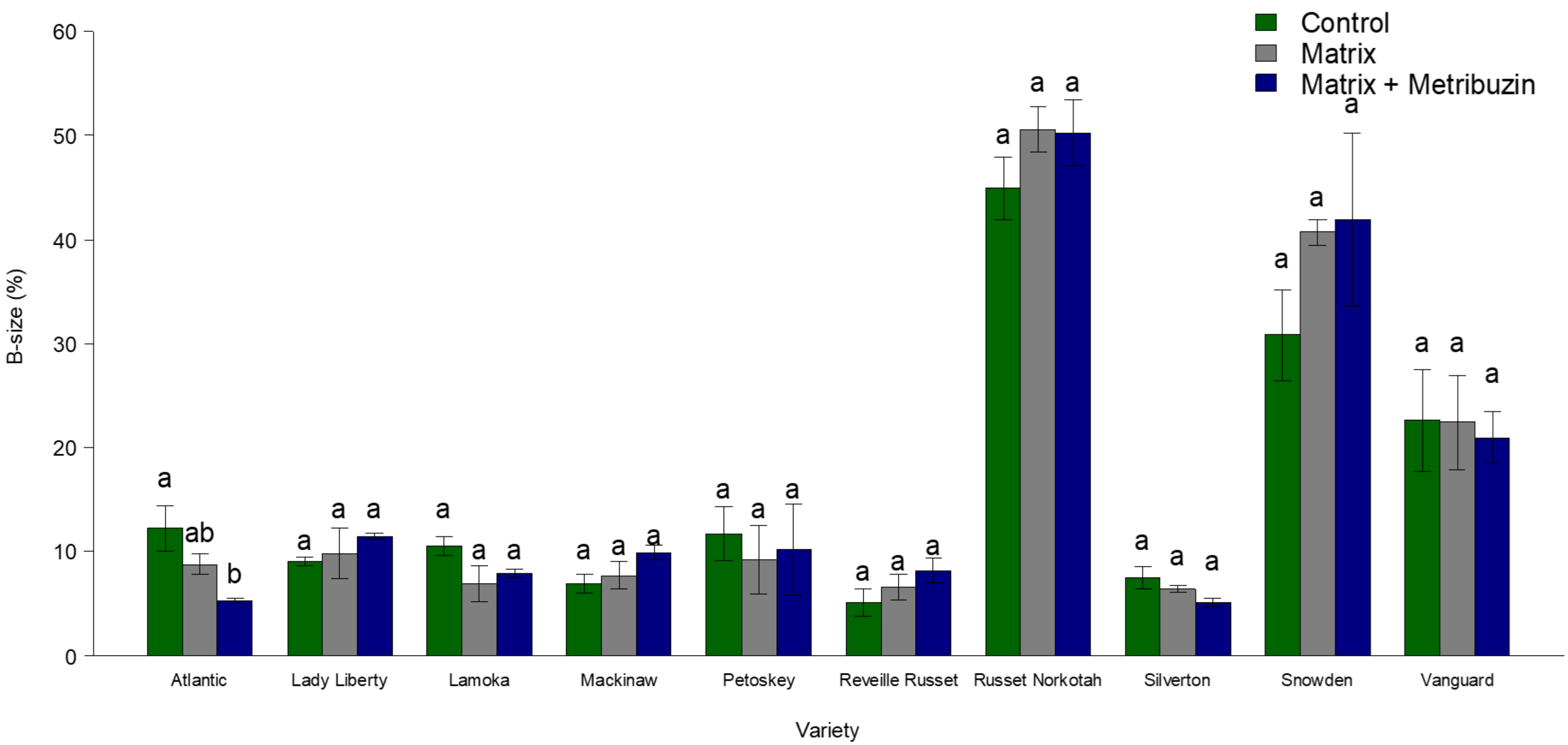


Figure 3. Potato B-size yield (%) for variety sensitivity 2022 trial at the Montcalm Research Center.

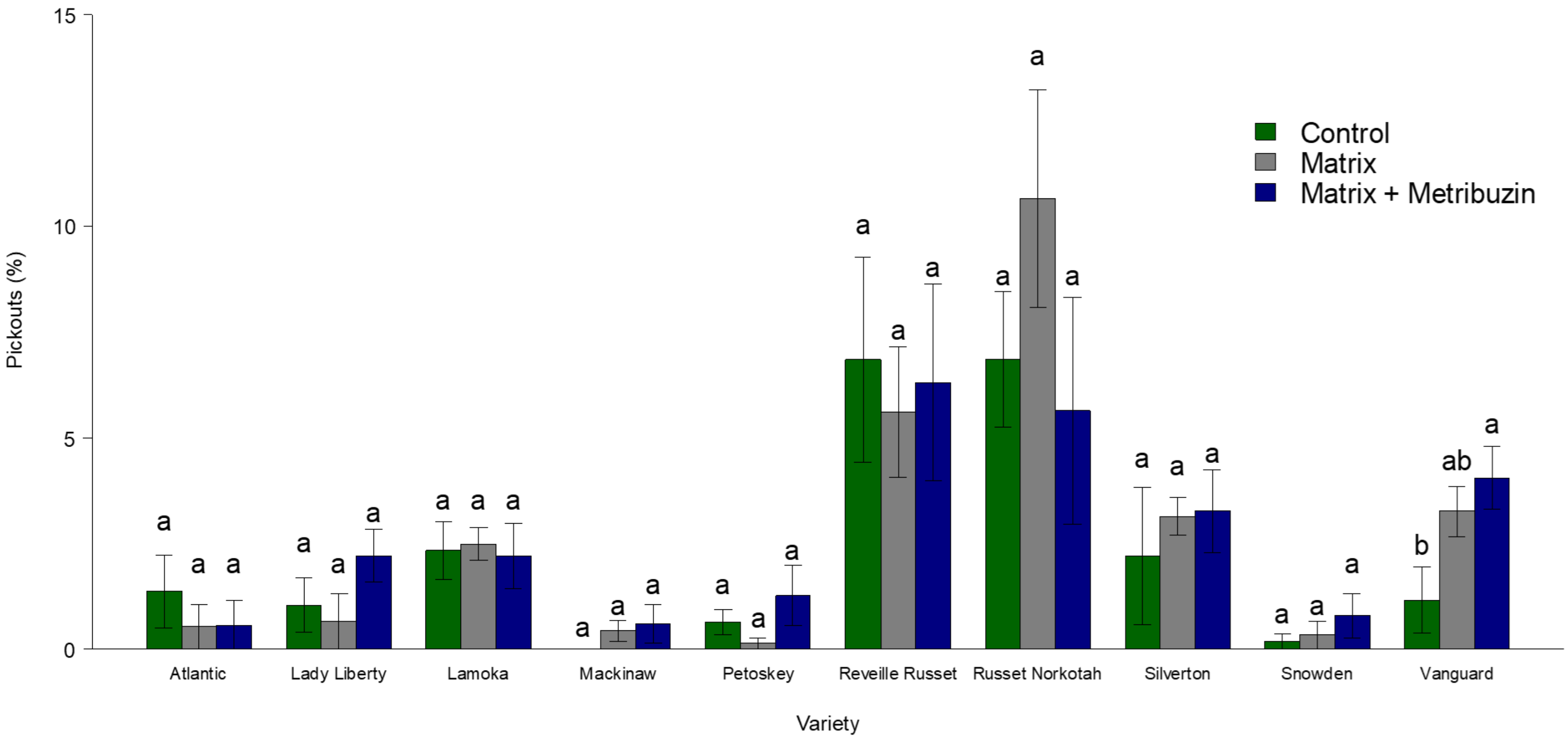


Figure 4. Potato pickouts (%) for variety sensitivity 2022 trial at the Montcalm Research Center.

Layering soil residual herbicides for troublesome weed control in potatoes-2022 MPIC Research Report

Erin Burns, Assistant Professor-Weed Science Extension Specialist
Department of Plant, Soil, and Microbial Sciences, Michigan State University

Many troublesome weeds (horseweed/marestail, waterhemp, palmer amaranth, common lambsquarters, and foxtails) in MI are shifting emergence patterns from a single early flush in the spring to extended emergence throughout the summer, therefore outlasting preemergence residual herbicide activity. Later emerging weeds can not only have yield impacts, but also be a harvest nuisance. Layering a residual soil-applied herbicide along with the postemergence herbicide pass is one way to maintain a barrier to weeds emerging later in the growing season. Therefore, objective two was to evaluate layering different group 14 (example Reflex), 15 (example Dual), and 3 (example Prowl) herbicides for season long weed control. All treatments except the control provided greater than 90% weed control 24 days after application after which postemergence herbicides were applied. Treatments that contained Dual postemergence (treatments 1, 3, 6, and 8) provided greater than 90% weed control throughout the duration of this study. Treatments that contained Prowl postemergence (treatments 2, 4, 7, and 9) did not control broadleaf weeds (palmer amaranth) later into the season, which was to be expected as Prowl does not control small seeded broadleaf weeds. Overall, results suggest both group 14 and 15 herbicides provide residual control and layering Dual postemergence will improve season long weed control. Treatment rates and plot photos (24 days after application) are presented in the table below. The Michigan Potato Industry Commission supported this research.

Michigan State University

Layering residuals for palmer amaranth control- SJ289

Trial ID: P01-22 Location: SJ289 Walther Farms Trial Year: 2022
Protocol ID: P01-22 Investigator (Creator): Erin Burns
Project ID: Study Director:
Sponsor Contact:

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Appl Timing	Appl Code	Rep 1	2	3	4	Notes
1	Dual II Magnum	7.64	L	1.33	pt/a	CRACK	A	101	209	304	401	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Dual II Magnum	7.64	L	1.33	pt/a	POST	B					
2	Dual II Magnum	7.64	L	1.33	pt/a	CRACK	A	102	204	302	408	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Prowl H2O	3.8	L	1.6	pt/a	POST	B					
3	Reflex	2	L	1	pt/a	CRACK	A	103	206	303	402	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Matrix	25	DF	1.5	oz/a	CRACK	A					
	Dual II Magnum	7.64	L	1.33	pt/a	POST	B					
4	Reflex	2	L	1	pt/a	CRACK	A	104	201	307	403	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Matrix	25	DF	1.5	oz/a	CRACK	A					
	Prowl H2O	3.8	L	1.6	pt/a	POST	B					
5	Untreated							105	203	301	406	
6	Valor SX	51	WG	1.5	oz/a	CRACK	A	106	208	309	407	
	Matrix	25	DF	1.5	oz/a	CRACK	A					
	Dual II Magnum	7.64	L	1.33	pt/a	POST	B					
7	Valor SX	51	WG	1.5	oz/a	CRACK	A	107	205	308	404	
	Matrix	25	DF	1.5	oz/a	CRACK	A					
	Prowl H2O	3.8	L	1.6	pt/a	POST	B					
8	Zidua SC	4.17	L	2.5	fl oz/a	CRACK	A	108	207	305	409	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Dual II Magnum	7.64	L	1.33	pt/a	POST	B					
9	Zidua SC	4.17	L	2.5	fl oz/a	CRACK	A	109	202	306	405	
	Lorox DF	50	DF	2	lb/a	CRACK	A					
	Prowl H2O	3.8	L	1.6	pt/a	POST	B					

Sort Order: Replicate 1


Treatment 1
Treatment 2
Treatment 3
Treatment 4
Treatment 5
Treatment 6
Treatment 7
Treatment 8


Treatment 9

Enhancing Soil Health in Michigan Potato Cropping Systems

Year End Report 2022

Participating Researchers
Kurt Steinke, Associate Professor, Dept. of Plant, Soil, and Microbial Sciences, Michigan State University
Lisa Tiemann, Associate Professor, Dept. of Plant, Soil, and Microbial Sciences, Michigan State University
Madelyn Celovsky, Graduate Research Assistant (M.S.) Michigan State University
Andrew Chomas, Research Specialist, Michigan State University

Introduction

The Potato Soil Health Project is a collaboration between 10 major potato growing states in the US. The collaboration's overall objective is "**to determine how best to measure soil health in potato cropping systems, identify the tools (cover crops, soil amendments, rotation schemes) that may enhance soil health and potato production, and communicate our findings to potato growers"**. To improve soil health in these systems is to improve the soil's ability to support tuber production as well as support carbon sequestration, water quality, pathogen suppression, and other important services. Across potato cropping systems, improving soil health can be difficult because of the mechanical and chemical disturbances utilized in production and due to much of the acreage occurring on coarse textured soil with a lower capacity for supporting SOM, retaining nutrients, soil aggregation, and microbial activity. Aside from drought, soilborne diseases represent the largest limitation to yield. In Michigan and nationally, Potato Early Die (PED) caused by *Verticillium* fungi and root lesion nematodes are particularly difficult to control and often require fumigation and/or nematicides. Carbon amendment may be able to mitigate the effects of fumigation and tillage on beneficial microbes.

Differences in climate, soil type, disease pressure, and economics across the US influence what kind of soil health building "tools" growers may have to utilize. In Michigan, manure applications and cover crops are increasingly used by growers to improve soil health, prevent erosion, and reduce nutrient leaching. Preplant applied manure contributes carbon along with other nutrients and supports microbial activity during the early stages of crop growth. A cover crop planted after corn harvest in a potato rotation can reduce soil erosion and nutrient leaching with the living roots and residues contributing carbon that supports microbial activity later into the season.

Evaluating how soil health building tools are influencing soil health can be difficult and changes may be slow. There are many emerging metrics and it is important to understand how soil health metrics may or may not be helpful in Michigan potato systems. The Potato Soil Health Project in Michigan is supported by funding from a USDA NIFA Specialty Crop Research Initiative (SCRI) grant, with additional funding support from the Michigan Potato Industry Commission and Michigan State University's AgBioResearch Project GREEEN. Two experimental trials were established at the Clarksville Research Station in 2019 with differing potato crop rotation length but with the same set of soil health management strategies, **The objective of the experiment was to evaluate the impacts of rotation length, soil fumigation, and organic amendments on soil health, soil borne pathogens, potato yield, and tuber quality across four years.**

Treatment Design

Field trials were established in Clarksville, MI on Lapeer sandy loam soils in May 2019. Soil health management and control treatments were designed to represent a range of management strategies for production potato varieties in Michigan (Table 1). Rotations consisted of corn, winter wheat, and potatoes every two (2-y rotation) or three (3-y rotation) years (Fig. 1). Center pivot irrigation applied around 8" of water throughout the potato growing seasons in 2019, 2020, and 2022. In rotation years, corn and wheat were supplemented with irrigation as needed. The Michigan-specific soil health management strategies included manure application (poultry litter; MANURE), a cover crop (cereal rye; COVER) or a combination of manure and a cover crop (MAN/CC) and a control with no soil health management included (GRSTAND). A non-fumigated control treatment with no other soil health improvement practices (NOFUM) was also included. For MANURE, MAN/CC, and GRSTAND, 'Superior', a disease susceptible round white tuber, was the variety planted. "Snowden', a chipping variety that is Scab susceptible though more tolerant to PED, was planted for the COVER treatment. The remaining treatment was a national control (NATCTRL) using 'Russet Burbank' which for this Michigan specific report we will not present results for or discuss.

In treatments with a cover crop (COVER and MAN/CC), cereal rye was planted after corn harvest at 55 lb A^{-1} seed and terminated by spring incorporation before planting potato. Manure treatments (MANURE and MAN/CC) contained poultry litter applied annually preplant incorporated at a rate of 1 ton A^{-1} for wheat and corn or 2 ton A^{-1} for potato. The fertility program between treatments varied. NATCTRL and COVER treatments both received 275, 100, and 300 lb A^{-1} of N, P2O5, and K2O, respectively, between planting and harvest. NOFUM and GRSTAND received 299, 100, and 300 lb A^{-1} with additional late season N for managing PED. MANURE and MAN/CC treatments received 344, 188, and 300 lb A^{-1} with 110, 128, and 96 lb A^{-1} coming from a first-year estimate of available nutrients from poultry litter. Fumigation was done before planting the first year of potatoes with either metam sodium (Vapam, 45 gal A^{-1}) or chloropicrin (Strike, 117 lb A^{-1}). Plot dimensions across studies were 11' wide by 50' long and utilized a five replicate randomized complete block design.

Methods

To track changes in soil biological, physical, and chemical soil properties, soil samples (0-6 inch) were taken post-harvest in rotation years and pre-plant and 60 days after planting (DAP) in potato years. Soil biological metrics represent a subset of the commercially available soil health tests. Autoclaved citrate extractable (ACE) protein is an estimate of soil protein and potentially mineralizable organic N. Permanganate oxidizable carbon (POX-C) is a management sensitive pool of microbially available C. C mineralization potential (Solvita 24 hr CO_2 respiration) captures general microbial activity. Phospholipid fatty acid (PLFA) profile estimates total microbial biomass along with fungal:bacterial (F:B) ratio. Outside of commercially available lab tests, microbial community structure was also analyzed using sequenced bacterial (16S) and fungal (ITS) regions of DNA in the soil. Soil physical metrics included compaction measured by a penetrometer to 18 inch and wet aggregate stability measured pre-plant potato, data not reported here. Standard nutrient analyses were performed at all sampling dates by a commercial lab.

Soil pathogen levels of *Verticillium dahliae* and *Pratylenchus penetrans* were quantified from 0-6” soil samples pre-plant potato and post-harvest rotation crops by a commercial lab. Percent green cover at vine kill was determined by visual evaluation in 2019 and 2020. In 2022, reported green cover was measured 1 month prior to study-wide early maturity and senescence. For wheat and corn, yield was measured utilizing a plot-combine with potato yields graded and weighed. Tuber quality was evaluated for specific gravity as well as infection of common scab (*Streptomycetes scabies*) and Verticillium.

Statistical analyses were performed in R using the *lme4* package for mixed model ANOVA. Poisson distribution was used to model Verticillium propagule counts and non-parametric testing was conducted using glmer in *lme4*. Estimates are reported on the count scale, though the estimated differences are modelled on the log scale. For microbial community analysis, Bray-Curtis dissimilarity coefficients were used to perform unconstrained Principal Coordinates Analysis (PCoA) and permutational ANOVA using the *vegan* package. Sequencing data from preplant and 60 DAP samples taken in 2019 and 2020 are presented with data from 2021 and 2022 samples forthcoming. Data from both sample dates within each year have been combined as no treatment by year interaction was found. To control for possible differences among varieties (Snowden and Russet are both longer season varieties) and fumigant in potato years, post-hoc hypothesis testing was conducted between treatments with Superior var. potatoes only (Table 1). Multiple degree of freedom contrast NOFUM vs MANURE compares the main effect of chloropicrin fumigation followed by annual application of manure to no fumigation and mineral fertilizers. MAN/CC and GRSTAND vs MANURE and MAN/CC compares the main effect of supplementing mineral fertility with annual poultry litter applications. Cereal rye cover crop establishment after corn in the MAN/CC treatment was poor so differences between MANURE and MAN/CC are not expected, especially in 2022. Contrasts were constructed using the emmeans package.

Results

First potato plantings- Fumigation by chloropicrin was effective in producing greater tuber yields compared to the nonfumigated control despite generally low initial soil pathogen levels in 2019 and 2020 (Table 2, $p = 0.0001$, Table 3). Attributing greater yields following fumigation to effective Verticillium and root lesion nematode control is difficult as fumigation did not impact Verticillium or root lesion nematode levels in the soil (Table 3). Further, the rate of tubers infected with Verticillium was not greater in the nonfumigated control compared to the chloropicrin treatments (Table 4). Percent green cover at vine kill was greater in chloropicrin fumigated treatments than in the nonfumigated control which may suggest less severe PED though green cover is also a metric of general plant vigor and may not be directly caused by Verticillium or root lesion nematode infection (Table 4).

Manure applications did not impact yield when compared to the fumigated control, nor did manure impact the Verticillium or root lesion nematode levels. MANURE and MAN/CC treatments had similar soil pathogens levels and yielded the same as GRSTAND in 2019 and 2020 (Tables 2 and 3).

Biological and physical soil metrics can be used to capture changes across a wide range of soil functions including nutrient cycling and disease suppression that are vital to tuber production. It is important to identify which metrics are sensitive to management in potato production systems and at which point it is most informative to test each one. The results identify the effects of fumigation and annual poultry litter application on metrics tested preplant and 60 days after planting (DAP) potatoes.

Chloropicrin fumigation resulted in lower bacterial and fungal diversity at both preplant and 60 DAP in the 2-year study (Table 5, $p = 0.0026$ and $p = 0.0074$ for bacteria, $p = 0.0003$ and $p = 0.0117$ for fungi). No fumigation effect was observed in the 3-year study in the weeks and months following fumigation except for a slight decrease in bacterial diversity at 60 DAP (Table 5, $p = 0.0004$). To compliment the alpha diversity estimate, principal components analysis (PCoA) and PERMANOVA estimate the beta diversity of the microbial communities using 16S and ITS sequencing data from soil DNA extracted from 2019 and 2020 soil samples. Figure 2 shows divergence in the bacterial and fungal communities sampled from the nonfumigated treatment (NOFUM) and all chloropicrin fumigated treatments (GRSTAND, COVER, MANURE, MAN/CC) in both the 2-year and 3-year study though the separation is less apparent in the 3-year study. In both the 2-year and 3-year study, the effect of chloropicrin fumigation on the microbial community structure seems to be weaker on bacteria than fungi. To quantify the separation of microbial community structures beyond illustration, a PERMANOVA was conducted. Confirming the PCoA results, chloropicrin fumigation resulted in altered bacterial and fungal communities in the weeks (preplant) and months (60 DAP) following fumigation and planting in the 2-year study (Table 6). No fumigation effect was seen on the bacterial community in the 3-year study and only the GRSTAND and MAN/CC fungal communities diverged from the NOFUM (Table 7).

Manure application did not impact microbial diversity or community structure in either study. Shannon diversity and pairwise comparison of Bray-Curtis differences reveal no difference between GRSTAND, MANURE and MAN/CC treatments (Table 5, Figure 2, Table 6, Table 7).

Though the effect of fumigation on microbial community quantified by sequence data was consistently observed in the 2-year study across treatments in 2020, the same cannot be said for other metrics of soil health. Fumigation and manure had no effect on preplant soil nutrient levels or pH in 2019 or 2020 (Table 8). Preplant levels of ACE protein, POX-C, and Solvita, indicators of microbial function, were not impacted by fumigation or manure application (data not shown). At 60DAP (90 days after fumigation) in 2020, chloropicrin fumigated treatments had POX-C lower than the nonfumigated treatment, though only in the 2-year rotation study (Table 9, $p=0.0015$). Manure application in the 2-year study resulted in higher microbial respiration rates (Solvita) at 60DAP (Table 9, $p=0.0138$). Neither fumigation or manure impacted ACE protein, Solvita, or POX-C levels at 60DAP in the 3-year study.

Second potato planting- To measure the carryover effects from the initial fumigation, all treatments were planted without fumigation in 2022. In both the 2-year and 3-year studies, Superior tubers yielded better in 2022 than in 2019/2020 overall with the exception being the 2-year GRSTAND in 2022 did not yield as well as the GRSTAND in 2020 (Table 2). The yield increase can most likely be attributed to earlier planting date in 2022. The fumigation advantage seen in the first round of potatoes in treatments with Superior did not extend to 2022. Treatments that were fumigated with chloropicrin in 2019/2020 (GRSTAND, MANURE, and MAN/CC) yielded the same as the NOFUM treatment in both the 2-year and 3-year rotation sites (Table 2, $p>0.05$). Similar yields across fumigated and nonfumigated treatments were preceded by similar soil pathogen levels. In the 2-year rotation, only the GRSTAND plots had elevated root lesion nematode values which may explain why these plots didn't yield better than 2020, even with the earlier planting date (Table 3). No differences in soil Verticillium or root lesion nematode levels were seen between NOFUM and the MANURE and MAN/CC treatments. Further, the 2019/2020 fumigation did not result in reduced Verticillium infection on tubers in 2022. In fact, the chloropicrin fumigated treatments had higher Verticillium infection compared to the nonfumigated control in 2022 (Table 3).

The cumulative effect of annual C amendment had a positive effect on total tuber yield in both the 2- and 3-year rotation. MANURE and MAN/CC treatments yielded on average 46 and 60 cwt A^{-1} higher than GRSTAND in the 2-year and 3-year rotations sites, respectively, in 2022 (Table 2, p =0.0356, p =0.0008). The impact of manure on soil pathogen levels and disease severity was variable in 2022. In both the 2-year and 3-yar studies, no difference were observed in green cover at vine kill between GRSTAND, MANURE, and MAN/CC in 2022. Verticillium infection rates were consistent amongst GRSTAND, MANURE and MAN/CC in the 2-year rotation. However, in the 3-year rotation, GRSTAND and MANURE tubers had surprisingly high Verticillium infection (44% and 48% of tubers infected), both greater than the NOFUM and MAN/CC (7% and 8% of tubers) (Table 4).

Fumigation showed no residual effect on soil nutrient levels or pH in 2022 (Table 8). Phosphorus levels in the soil measured at potato planting in both the 2-year and 3-year studies were higher in 2022 than when initially measured in Spring 2019/2020 (Table 8). Accumulation of P in treatments with annual application of poultry litter was not greater than in treatments without manure as may be expected with the higher P application rates received by treatments with manure (MANURE and MAN/CC) (Table 8). Treatments with manure were being supplied about 60 and 80 lbs P A^{-1} more than the mineral fertilizer treatments in rotation and potato years, respectively. The extra P could have contributed to the higher tuber yields in manure treatments compared to the GRSTAND and NOFUM (Table 2), though P levels should not have been limiting yield with 100 lbs P A^{-1} being applied in-furrow as 10-34-0 to GRSTAND and NOFUM. The similar P concentrations despite higher rates of applied P in manure treatments compared to treatments without manure could be because of the relatively low CEC (3.4-6.3 meq/100 g^{-}) of the soils across the studies with little potential for adsorption or due to the relatively low rates of manure being applied annually. By 60DAP in 2019 and 2020, there was still no difference in nutrient levels between treatments. Soil nutrient data for 60DAP in 2022 are forthcoming.

In the 3-year rotation site, the PLFA analysis from 2022 60DAP samples revealed MANURE and MAN/CC treatments resulted in a higher F:B and higher total microbial biomass compared to the NOFUM and GRSTAND though only the MANURE was significantly higher (Table 10). No difference was observed in the F:B in the 2-year rotation. Though this can be interpreted simply as a change in microbial community, a higher F:B is often associated with a change in soil function as well. Fungi are important for residue breakdown and may have an important role in pathogen suppression, but fungi are sensitive to the disturbances of managed systems like tillage and fumigation. An increase in F:B ratio is often used as an indication of healthy soil. Forthcoming alpha and beta diversity data from 2021 and 2022 along with the soil health data will be important in understanding fumigation’s lasting impact on the diversity, community structure, and function of soil microbes in this system.

Appendix

Table 1. Experimental treatments in both the 2-y and 3-y rotation experiments. Fumigation was done only once prior to potato planting, in year 2 of the 2-y rotation and in year 1 of the 3-y rotation. Manure applications were done each year and cover crops were planted only once per rotation, between years 1-2 in the 2-y rotation and between years 3-4 in the 3-y rotation (Fig. 1).

Treatment	**Abbreviation**	**Variety**	**Fumigation**	**Manure**	**Cover Crop**
National control	NATCTRL	Russet burbank	Metam sodium	N	N
No fumigation control	NOFUM	Superior PED susceptible	None	N	N
Grower Standard	GRSTAND	Superior PED susceptible	Chloropicrin	N	N
Fumigated/manure	MANURE	Superior PED susceptible	Chloropicrin	Poultry litter	N
Fumigated/cover crop	COVER	Snowden PED tolerant	Chloropicrin	N	Cereal rye
“Kitchen Sink”	MAN/CC	Superior PED susceptible	Chloropicrin	Poultry litter	Cereal rye

Figure 1. Timeline of long-term rotational study. ❋ signify sampling dates, ⬇ poultry litter applications (rate of 1- or 2-tons A^{-1}), and ✦ fumigation timing.

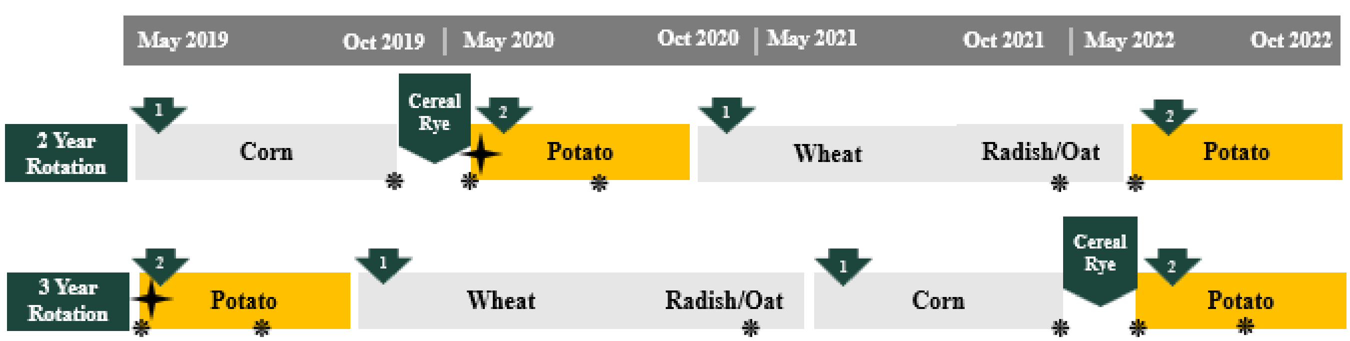


Table 2. Potato and rotation crop yield from 2-year and 3-year rotation sites in Clarksville, MI.

Rotation Site	Treatment	Variety	Potato Total Yield (cwt A^{-1}) 2020 / 2019[a]	Potato Total Yield (cwt A^{-1}) 2022	Wheat Yield (bu A^{-1}) 2021 / 2020	Corn Yield (bu A^{-1}) 2019 / 2021
2 Year	NOFUM	Superior	57 a†	185 ab	89 abc	121
	GRSTAND	Superior	156 b	144 a	92 bc	119
	MANURE	Superior	175 b	198 bc	96 c	122
	COVER	Snowden	260 c	245 c	82 ab	117
	MAN/CC	Superior	167 b	228 bc	90 bc	121
	Pr > F		<0.0001	0.0116	0.0332	ns
NOFUM vs GRSTAND, MANURE, and MAN/CC.[b]			+109	-	-	-
		Pr>t	0.0001	ns‡	ns	ns
GRSTAND vs MANURE & MAN/CC[c]			-	+46	-	-
		Pr>t	ns	0.0356	ns	ns
3 Year	NOFUM	Superior	80 a	233 a	91 bc	208
	GRSTAND	Superior	146ab	219 a	83 abc	215
	MANURE	Superior	122a b	309 b	95 c	221
	COVER	Snowden	191 b	264 ab	75 a	222
	MAN/CC	Superior	180 b	248 a	81 ab	233
	Pr > F		0.024	0.0178	0.0403	ns
NOFUM vs GRSTAND, MANURE, and MAN/CC.[b]			+70	-	-	-
		Pr>t	<0.0001	ns	ns	ns
GRSTAND vs MANURE & MAN/CC[c]			-	+60	-	-
		Pr>t	ns	0.0080	ns	ns

[a] 2Y rotation 2019 corn, 2020 potato, 2021 wheat, 2022 potato. 3Y rotation 2019 potato, 2020 wheat, 2021 corn, 2022 potato.
[b] Multiple degree of freedom contrast. Compares yield of Superior tubers planted without fumigation to all those fumigated with chloropicrin before planting in 2019/2020.
[c] Multiple degree of freedom contrast. Compares treatment that received mineral fertilizer only to those that were supplemented with annual application of poultry litter.
† Values within the same site and year followed by the same lowercase letter are not significantly different at α=0.05.
‡ ns, not significant.

Table 3. Verticillium dahliae and root lesion nematode (Pratylenchus penetrans) levels from preplant potato soil samples.

Rotation Site	Treatment	Variety	Verticillium propagules per gram soil				Pratylenchus penetrans per 100 cc soil			
			Preplant 2020/ 2019 [a]	60DAP 2020/ 2019	Preplant 2022	60DAP 2022	Preplant 2020/ 2019	60DAP 2020/ 2019	Preplant 2022	60DAP 2022
2 Year	NOFUM	Superior	1 ab†	3 a	12 a	12 ab	74	68	670 a	389 ab
	GRSTAND	Superior	0 a	1 a	20 b	17 b	50	37	999 b	676 c
	MANURE	Superior	0 a	1 a	21 b	12 ab	79	84	772 a	531bc
	COVER	Snowden	1 ab	1 a	13 a	15 ab	79	68	610 a	465 ab
	MAN/CC	Superior	0 a	0 a	20 b	8 a	47	26	682 a	342 a
	Pr > F		- [b]	-	-	-	ns	ns	0.015	0.015
3 Year	NOFUM	Superior	0 a	-	1 ab	4 b	76	-	101	250
	GRSTAND	Superior	0 a	-	0 a	0 ab	68	-	54	565
	MANURE	Superior	0 a	-	1 ab	1 ab	51	-	99	441
	COVER	Snowden	1 a	-	3 c	0 a	83	-	54	423
	MAN/CC	Superior	0 a	-	2 bc	0 a	59	-	139	390
	Pr > F		-	-	-	-	ns	-	ns	ns

[a] 2 Year rotation study was potatoes planted in 2020 and 2022, 3 Year rotation study potatoes planted 2019 and 2022.
[b] Verticillium propagule count modeled with Poisson distribution and compared using nonparametric hypothesis testing
[c] Verticillium and Pratylenchus levels not sampled from 2 Year rotation study 60DAP in 2019.
† Values within the same column and site followed by the same lowercase letter are not significantly different at α=0.05.
‡ ns, not significant.

Table 4. Potato tuber quality and green cover at vine kill from 2-Year and 3-Year Rotation.							
			% Tubers with Verticillium Rings		**Green Cover at Vine Kill (%)**		**% Tubers with Scab**
Rotation Site	**Treatment**	**Variety**	**2020/ 2019[a]**	**2022**	**2020/ 2019[a]**	**2022**	**2022**
2 Year	NOFUM	Superior	-	2 ab	5 a	5 a	26 ab
	GRSTAND	Superior	-	3 abc	14 ab	17 b	8 a
	MANURE	Superior	-	7 bc	15 ab	18 b	14 a
	COVER	Snowden	-	14 c	6 a	30 c	52 b
	MAN/CC	Superior	-	2 a	18 b	13 ab	7 a
	Pr > F		-	- ‡	0.0009	0.0001	-
3 Year	NOFUM	Superior	16 ab	7 a	8 a	21 ab	6 a
	GRSTAND	Superior	5 a	44 b	15 a	18 a	54 b
	MANURE	Superior	7 ab	48 b	13 a	29 bc	57 b
	COVER	Snowden	16 ab	38 b	32 b	33 c	58 b
	MAN/CC	Superior	7 ab	8 a	13 a	25 abc	12 a
	Pr > F		-	-	<0.0001	<0.0001	-

[a] 2Y Rotation potatoes harvested in 2020 & 2022, 3Y Rotation potatoes harvested 2019 & 2022. Verticillium infection rate not observed in 2020 tubers (2 Year rotation).
† Values within column and site followed by the same lowercase letter are not significantly different at α=0.05.
‡ Verticillium and scab infection rates modeled with negative binomial distribution and compared using nonparametric hypothesis testing

Table 5. Shannon diversity estimated from 16S (bacterial) and ITS (fungal) gene sequencing. Data for 2021 and 2022 forthcoming.

Rotation Site	**Treatment**	**Bacterial Shannon Diversity**		**Fungal Shannon Diversity**	
		Preplant 2020 2019	**60DAP 2020 2019**	**Preplant 2020 2019**	**60DAP 2020 2019**
2 Year	NOFUM	8.0 b	8.1 c	4.8 b†	4.8 c
	GRSTAND	7.7 a	7.9 bc	4.4 a	4.4 abc
	MANURE	7.6 a	7.8 ab	4.5 a	4.2 a
	COVER	7.7 ab	7.9 bc	4.6 a	4.4 ab
	MAN/CC	7.5 a	7.6 a	4.4 a	4.1 a
	Pr > F	0.0061	0.0060	0.0003	0.0117
NOFUM vs GRSTAND, MANURE, COVER, and MAN/CC [b]		-0.48	-0.256	-0.36	-0.49
	Pr>t	0.0026	0.0074	0.0004	0.0019
GRSTAND vs MANURE & MAN/CC[c]		-	-	-	-
	Pr>t	ns‡	ns	ns	ns
3 Year	NOFUM	8.0	8.0	5.0	4.8
	GRSTAND	7.8	7.7	4.9	4.6
	MANURE	7.9	7.6	4.8	4.7
	COVER	7.9	7.6	4.9	4.7
	MAN/CC	8.0	7.5	4.8	4.6
	Pr > F	ns	0.0131	ns	ns
NOFUM vs GRSTAND, MANURE, COVER, and MAN/CC [b]		-	-0.348	-	-
	Pr>t	ns	0.0004	ns	ns
GRSTAND vs MANURE & MAN/CC[c]		-	-	-	-
	Pr>t	ns	ns	ns	ns

[a] 2Y Rotation potatoes planted in 2020, 3Y Rotation potatoes planted 2019.
[b] Multiple degree of freedom contrast. Compares yield of Superior tubers planted without fumigation to all those fumigated with chloropicrin before planting in 2019/2020.
[c] Multiple degree of freedom contrast. Compares treatment that received mineral fertilizer only to those that were supplemented with annual application of poultry litter.
† Values within the same site and year followed by the same lowercase letter are not significantly different at α=0.05.
‡ ns, not significant.

Figure 2. Ordination by principal coordinates analysis (PCoA) plots of amplicon sequence variant level soil bacteria, (A) and (B), and fungi, (C) and (D), illustrating clustering of community structure by treatment. Soil DNA extracted from samples taken in 2019 (3 Year rotation) and 2020 (2 Year rotation). The principal coordinates analysis plot was built based on Bray–Curtis distances. The percentage of total variance explained by each axis of the first two defined axes is shown.

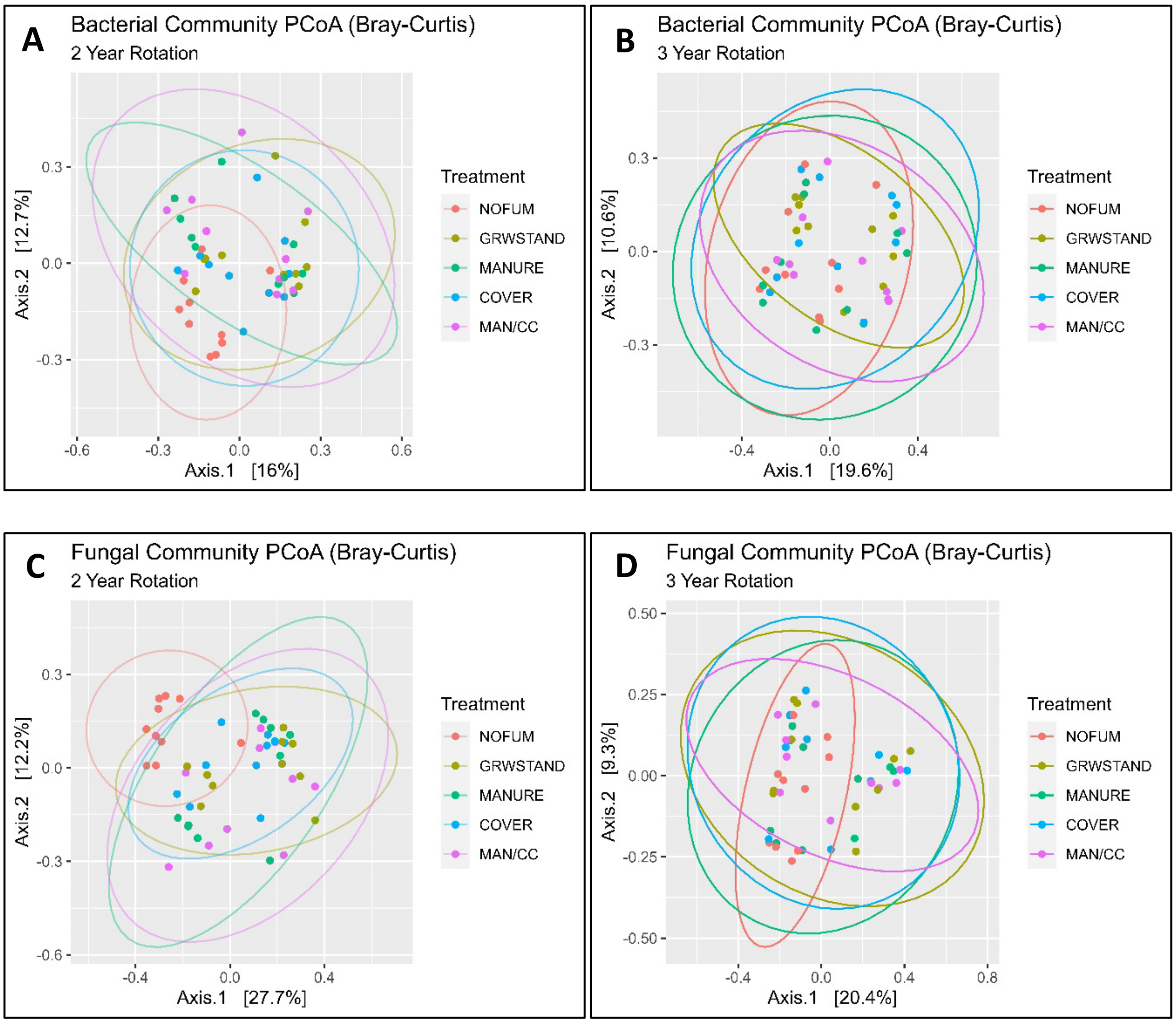


Table 6. P-values of pairwise PERMANOVA comparison of bacterial (16S) and fungal (ITS) communities by treatment from 2 Yr rotation study. Bray Curtis distances. Samples from 2020 preplant and 60DAP following fumigation in May. ns, not significantly different at α=0.05.

2 Yr 16S	NOFUM	GRSTAND	MANURE	COVER	MAN/CC
NOFUM					
GRSTAND	0.0003				
MANURE	0.0001	ns			
COVER	0.0013	ns	ns		
MAN/CC	0.0001	ns	ns	ns	
2 Yr ITS	NOFUM	GRSTAND	MANURE	COVER	MAN/CC
NOFUM					
GRSTAND	0.0001				
MANURE	0.0002	ns			
COVER	0.0002	ns	ns		
MAN/CC	0.0001	ns	ns	ns	

Table 7. P-values of pairwise PERMANOVA comparison of bacterial (16S) and fungal (ITS) communities by treatment from 3 Yr (Year) rotation study. Modeled with Bray-Curtis distances. Samples from 2019 preplant and 60DAP following fumigation in May. ns, not significantly different at α=0.05.

3 Yr 16S	NOFUM	GRSTAND	MANURE	COVER	MAN/CC
NOFUM					
GRSTAND	ns				
MANURE	ns	ns			
COVER	ns	ns	ns		
MAN/CC	ns	ns	ns	ns	
3 Yr ITS	NOFUM	GRSTAND	MANURE	COVER	MAN/CC
NOFUM					
GRSTAND	0.0216				
MANURE	ns	ns			
COVER	ns	ns	ns		
MAN/CC	0.0092	ns	ns	ns	

Table 8. Pre-plant soil nutrient levels and chemical properties from potato years 2-Year and 3-Year Rotation sites.

Rotation Site	Treatment	N-Nitrate ppm		P (Mehlich-3) ppm		K ppm		pH		OM %	CEC meq $100g^{-1}$
		2020 2019 [a]	2022	2020 2019	2022	2020 2019	2022	2020 2019	2022	2022[b]	2022 [b]
2 Year	NOFUM	34.5	6.6	95	115	137	171	6.7	6.6a†	1.8	6.2
	GRSTAND	33.8	7.2	102	109	128	166	6.4	6.5a	1.8	6.0
	MANURE	36.9	6.6	96	127	121	168	6.5	6.8bc	1.9	5.7
	COVER	31.3	5.5	92	132	123	156	6.5	6.5a	1.8	6.2
	MAN/CC	31.9	5.4	90	109	108	156	6.6	6.8c	1.9	5.8
	P > F	ns‡	ns	ns	ns	ns	ns	ns	0.001	ns	ns
3 Year	NOFUM	5.8	5.5	149	223	81	124	6.0	6.2	1.4	4.9
	GRSTAND	5.4	7.8	151	221	82	131	5.8	6.0	1.2	4.0
	MANURE	6.8	6.3	135	217	90	109	6.1	6.3	1.3	4.7
	COVER	5.3	4.8	154	209	68	98	5.9	6.1	1.1	4.2
	MAN/CC	5.9	7.3	117	194	83	122	5.8	6.1	1.4	4.1
	P > F	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[a] 2Y Rotation potatoes planted in 2020 & 2022, 3Y Rotation potatoes planted 2019 & 2022.
[b] OM and CEC did not significantly change over the 4 years of the study, only 2022 values reported.
† Values within the same site and year followed by the same lowercase letter are not significantly different at α=0.05.
‡ ns, not significant.

Table 9. Carbon mineralization (Solvita), active carbon (POX-C) and soil protein (ACE protein) measured at 60DAP in the first round of potatoes (2YR July 2020, 3YR July 2019). Results from the 2022 planted potatoes forthcoming.

Rotation Site	Treatment	Solvita	POX-C	ACE Protein
		ppm	ppm	$mg\ g^{-1}$
2 Year	NOFUM	70ab†	406b	3.6
	GRSTAND	65a	368ab	4.0
	MANURE	78b	354a	3.9
	COVER	66a	336a	3.8
	MAN/CC	77ab	351a	3.7
	Pr>F	0.0242	0.0268	ns
NOFUM vs GRSTAND, MANURE, COVER, and MAN/CC.[a]		-	-53.8	-
	Pr>t	ns	0.0015	ns
GRSTAND vs MANURE & MAN/CC [b]		+12.9	-	-
	Pr>t	0.0138	ns	ns
3 Year	NOFUM	147	319	4.6
	GRSTAND	155	331	4.0
	MANURE	152	356	4.5
	COVER	133	255	3.9
	MAN/CC	167	333	4.3
	Pr>F	ns ‡	ns	ns
NOFUM vs GRSTAND, MANURE, COVER, and MAN/CC.[a]		-	-	-
	Pr>t	ns	ns	ns
GRSTAND vs MANURE & MAN/CC [b]		-	-	-
	Pr>t	ns	ns	ns

[a] Multiple degree of freedom contrast. Compares nonfumigated to all chloropicrin fumigated treatments

[b]Multiple degree of freedom contrast. Compares treatment that received mineral fertilizer only to those that were supplemented with annual application of poultry litter.

† Values followed by the same lowercase letter are not significantly different at α=0.05.

‡ ns, not significant.

Table 10. Total microbial biomass and ratio fungi:bacteria (F:B) estimated by PLFA biomarkers. Measured from samples taken 60 DAP in second round of potatoes (2022).

Rotation Site	**Treatment**	**Total Microbial Biomass** ng/g soil	**F:B**
2 Year	NOFUM	3104	0.19
	GRSTAND	2595	0.17
	MANURE	2380	0.18
	COVER	2010	0.18
	MAN/CC	2905	0.21
	Pr> F	ns‡	ns
3 Year	NOFUM	1491 a†	0.08 ab
	GRSTAND	1628 a	0.04 a
	MANURE	2119 b	0.16 c
	COVER	1511 a	0.07 ab
	MAN/CC	1542 a	0.12 bc
	Pr> F	0.0456	0.0094

† Values followed by the same lowercase letter are not significantly different at α=0.05.
‡ ns, not significant.

Michigan Potato Industry Commission Grant Proposal 2022 Report
Project Title: *Verticillium* spp. potato field survey across Michigan
Investigator: Marisol Quintanilla
Collaborator: Dr. Jaime Willbur

Introduction

Historically, effective control of PED has been accomplished with broad-spectrum fumigants such as Metam sodium (Vapam; AMVAC) or 1,3-dichloropropene (Telone II, Corteva Agriscience). However, in recent years, growers have become more interested in non-fumigant control to reduce costs and improve soil health. Therefore, many new nematicides and fungicides have been produced. For the control of *V. dahliae*, synthetic fungicides like fluopyram (Velum® Prime, Bayer) and azoxystrobin and benzovindiflupyr (Elatus®, Syngenta) have been developed and for *P. penetrans* management, oxamyl (Vydate® L, Corteva Agriscience) has been used to reduce the effects of the root-lesion nematode. However, it is important to establish the effectiveness of different products on the different representative isolates found on Michigan potato fields. With the funds and comments provided by the MPIC, we determined the response of two Michigan isolates and one isolate from Wisconsin to two chemical-based fungicides and 7 biological control agents that are available in the market for Verticillium wilt control in potatoes.

Materials and Methods

Two different Verticillium isolates were obtained from two different locations in Michigan potato fields. Stem tissue was plated on verticillium media until pure cultures were obtained (**Figure 1**). Later, each colony was submitted to the MSU diagnostics lab for molecular analysis to confirm that those pure cultures were indeed *Verticillium dahliae*. Meanwhile, 7 different microbial antagonists (**Table 1**) were isolated from their respective formulation and once pure cultures were obtained, DNA was extracted and submitted for sequencing. Lastly, a BLAST search was conducted to confirm that those colonies were what we expected (**Figure 2**).

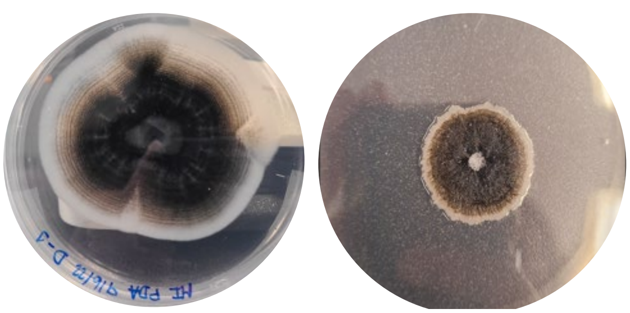


Figure 1. *V. dahliae* isolate 1 (right) and *V. dahliae* isolate 2 (left)

Table 1. Products evaluated for *V. dahliae* growth suppression with their respective active ingredient/s

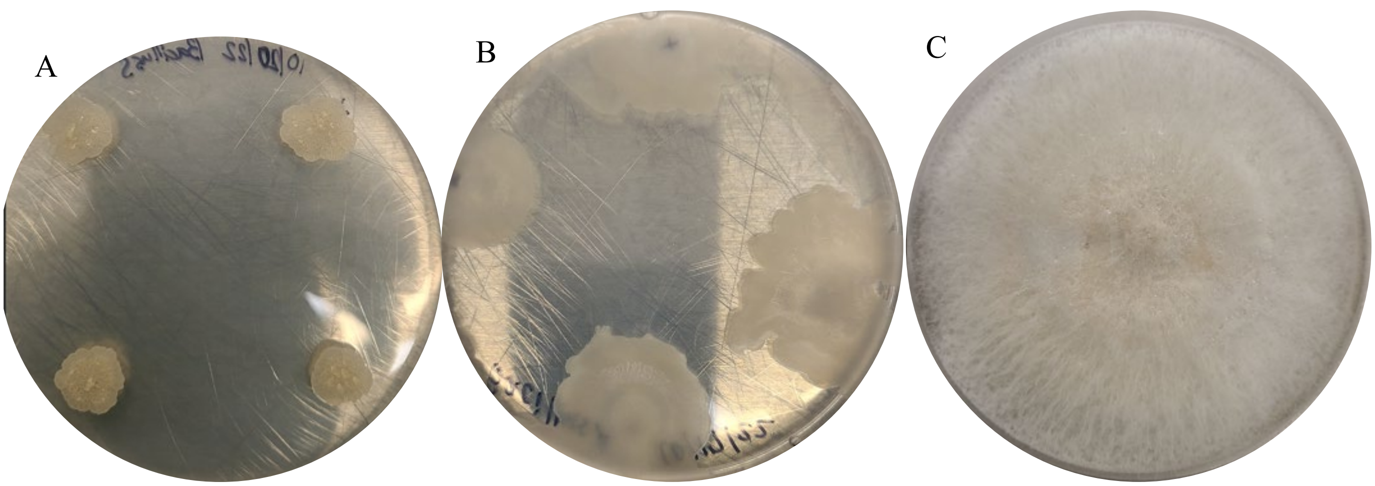
Product	Active Ingredient
Elatus	Azoxystrobin & benzovindiflupyr
Quadris	Azoxystrobin
Minuet	*Bacillus subtilis*
Double Nickel	*Bacillus amyloliquefaciens*

Lalstop	*Gliocladium catenulatum*
Actinovate AG	*Streptomyces lydicus*
Tenet	*Trichoderma gamsii*
Tenet	*Trichoderma asperellum*
MeloCon	*Paecelomyces lilacinum*

After confirmation, each microorganism was cultured on PDA for mass production for the bioassays. Once ready, dual culture assays were established on PDA media (fungi) and LB media (bacteria) to determine the effect of the antagonists and chemical-based fungicides on the different Verticillium isolates. As controls, each microorganism was cultured alone on PDA media. Radial growth of Verticillium and the antagonists was done every other day for 15 days and % of inhibition was calculated with the following formula

$$PI = (D - d)/D) * 100$$

PI = Inhibition of pathogen growth (%); D = diameter of pathogen growth in control plates (mm); d = diameter of pathogen growth for the tests (mm).



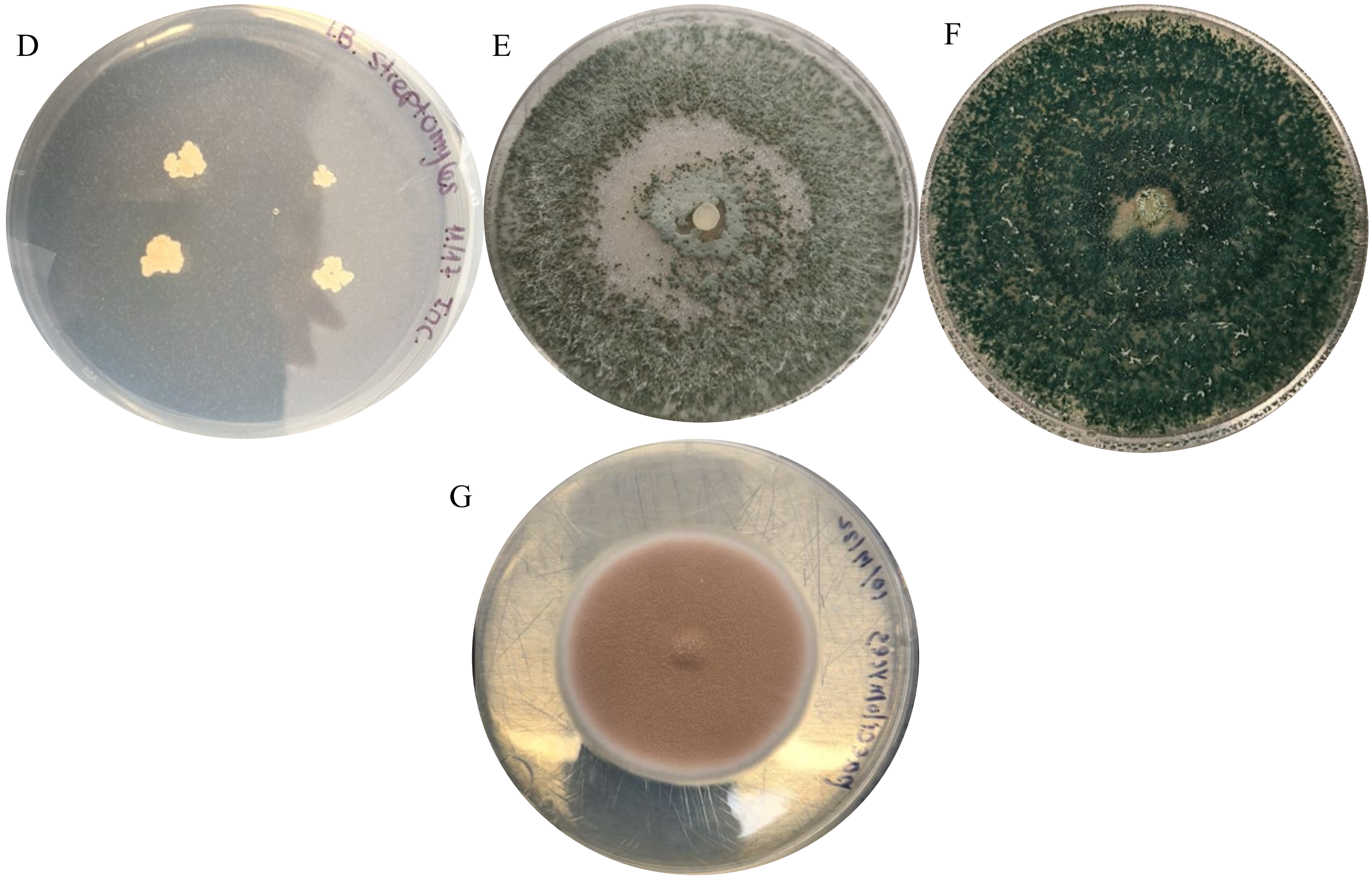


Figure 2. A. *B. subtilis*, **B.** *B. amyloliquefaciens*, **C.** *G. catenulatum*, **D.** *S. lydicus*, **E.** *T. gamsii*, **F.** *T. asperellum* and **G.** *P. lilacinum*

Results and Conclusions

A. *V. dahliae* isolate 1 response to the different antagonists and fungicides evaluated after15 days of growth

Isolate 1		
Antagonist	**Average Vert. Growth**	**% Inhibition**
Control (Vert alone)	2.8	-
B. subtilis	1.4	49
B.amyloliquefaciens	2.1	21
S. lydicus	1.3	52
T. gamsii	1.4	Trichoderma colonized Vert colony
T. asperellum	1.2	Trichoderma colonized Vert colony
P. lilacinum	2.3	19

G. catenulatum	2.7	19
Elatus	Grew only on PDA disk	100
Quadris	1.3	52

B. *V. dahliae* isolate 2 responses to the different antagonists and fungicides evaluated after15 days of growth

Isolate 2		
Antagonist	**Average Vert. Growth**	**% Inhibition**
Control (Vert alone)	2.82	-
B. subtilis	1.5	47
B.amyloliquefaciens	1.6	43
S. lydicus	1.6	43
T. asperellum	1.4	Trichoderma colonized Vert colony
T. gamsii	1.3	Trichoderma colonized Vert colony
P. lilacinum	2.27	20
G. catenulatum	2.56	10
Elatus	Grew only on PDA disk	100
Quadris	2	30

C. *V. dahliae* isolate 3 responses to the different antagonists and fungicides evaluated after15 days of growth

Isolate 3		
Antagonist	**Average Vert. Growth**	**% Inhibition**
Control (Vert alone)	3.5	-
B. subtilis	1.5	57
B.amyloliquefaciens	2	43
S. lydicus	1.8	49
T. asperellum	1.5	Trichoderma colonized Vert colony
T. gamsii	1.5	Trichoderma colonized Vert colony
P. lilacinum	2.3	34
G. catenulatum	2.6	26
Elatus	Grew only on PDA disk	100
Quadris	1.9	56

The three isolates responded similarly to the different antagonists as well as to the chemical fungicides. For Vert Isolate 1, the antagonists that showed the less performance (<30%) were

B.amyloliquefaciens, P. lilacinum and *G. catenulatum.* While for Vert Isolate 2, were *P. lilacinum* and *G. catenulatum* and for Isolate 3 was *G. catenulatum*. For all three isolates, the antagonists that had the greatest performance (>50%) were *T. asperellum, T. gamsii* and *B. subtili.* Interestingly, for the 3 Vert isolates, the Trichorderma species started growing over the Verticillium colonies just after 4 days of inoculation. By the 15th day, the Trichoderma species had totally grown on and beyond Verticillium (Figure 3).

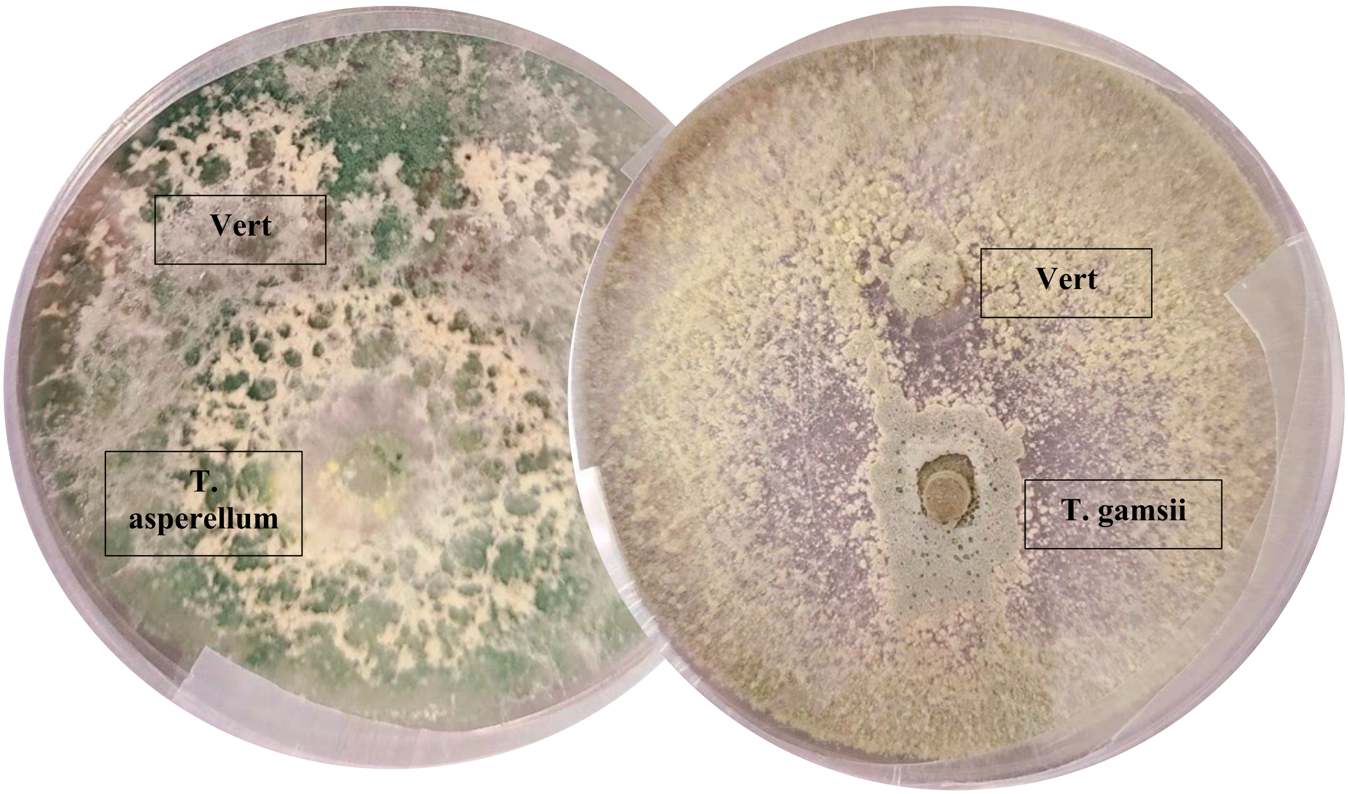


Figure 3. Growth of Trichoderma species over Verticillium colonies at 15 days of incubation

As for the Bacillus species, an interesting observation was that the Verticillium isolates were growing away from the bacteria colonies, avoiding to get in contact with them (Figure 4) and despite the slow growth of *S. lydicus* , the Verticillium growth was slowed down in comparison to the control (Figure 5)

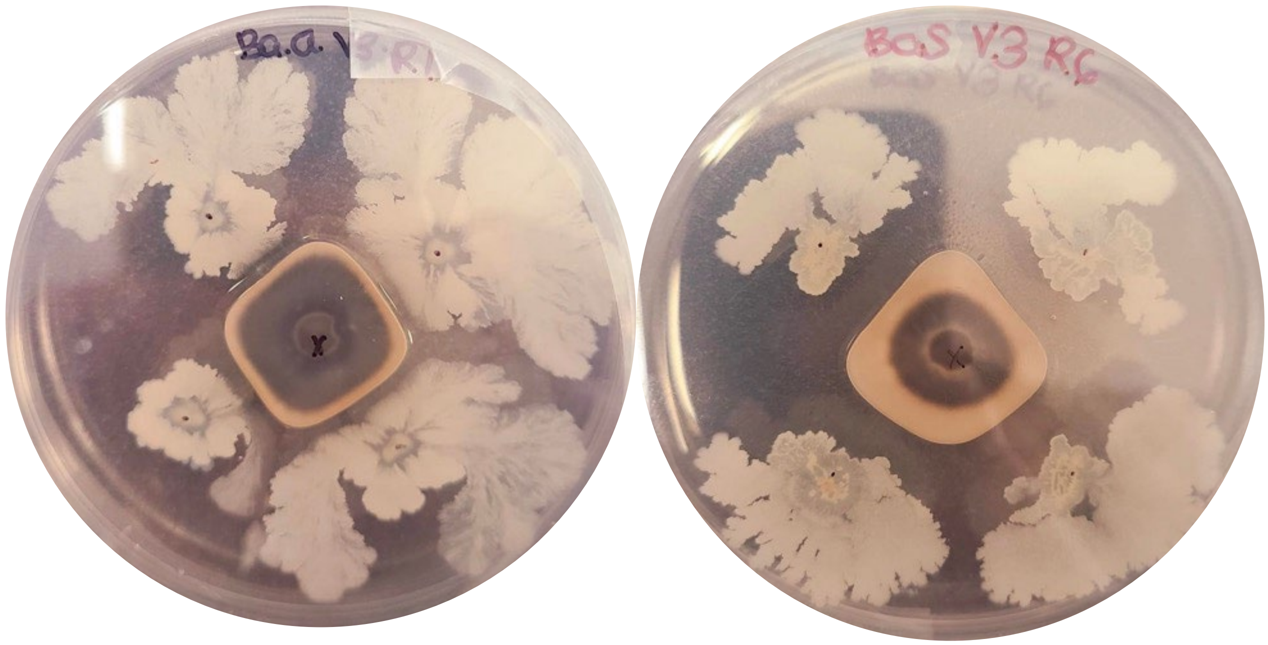


Figure 4. Growth of Verticillium colonies avoiding contact with either Bacillus species

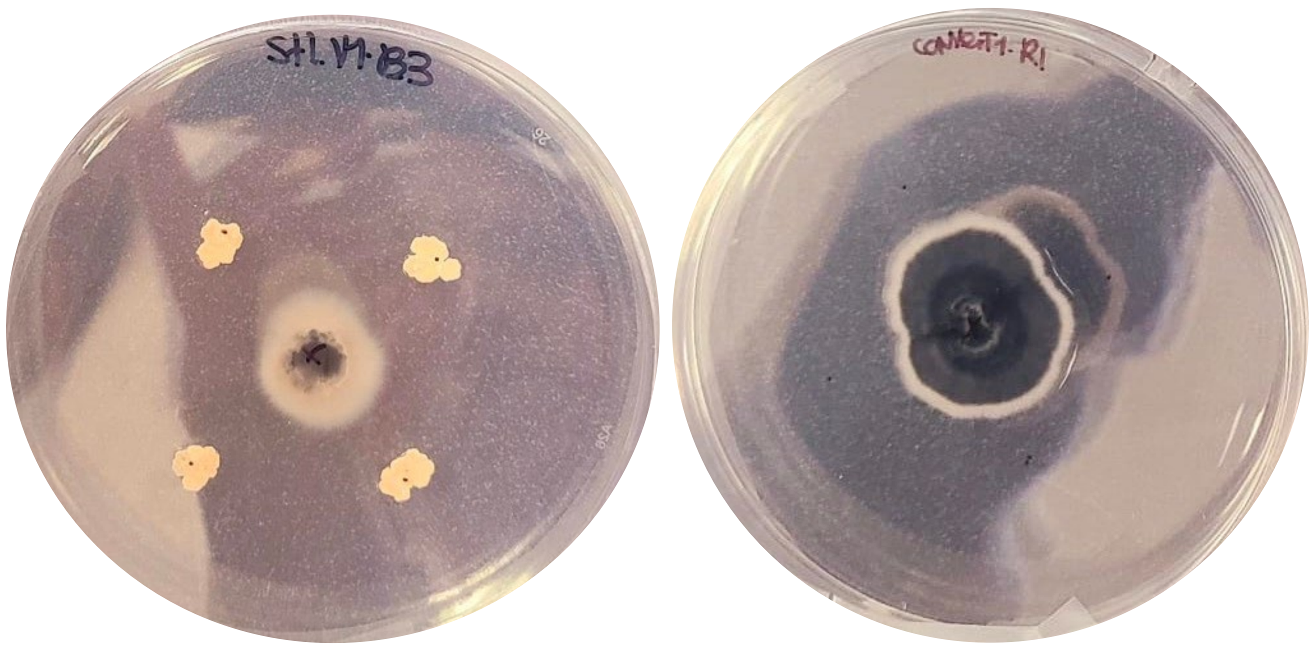


Figure 5. Reduced growth of Verticillium colonies when grown with *S. lydicus*, in comparison to the control

Neither of the Vert colonies seemed to be affected by neither *G. catenulatum* nor *P. lilacinum*. Both organisms showed similar growth rates (Figure 6).

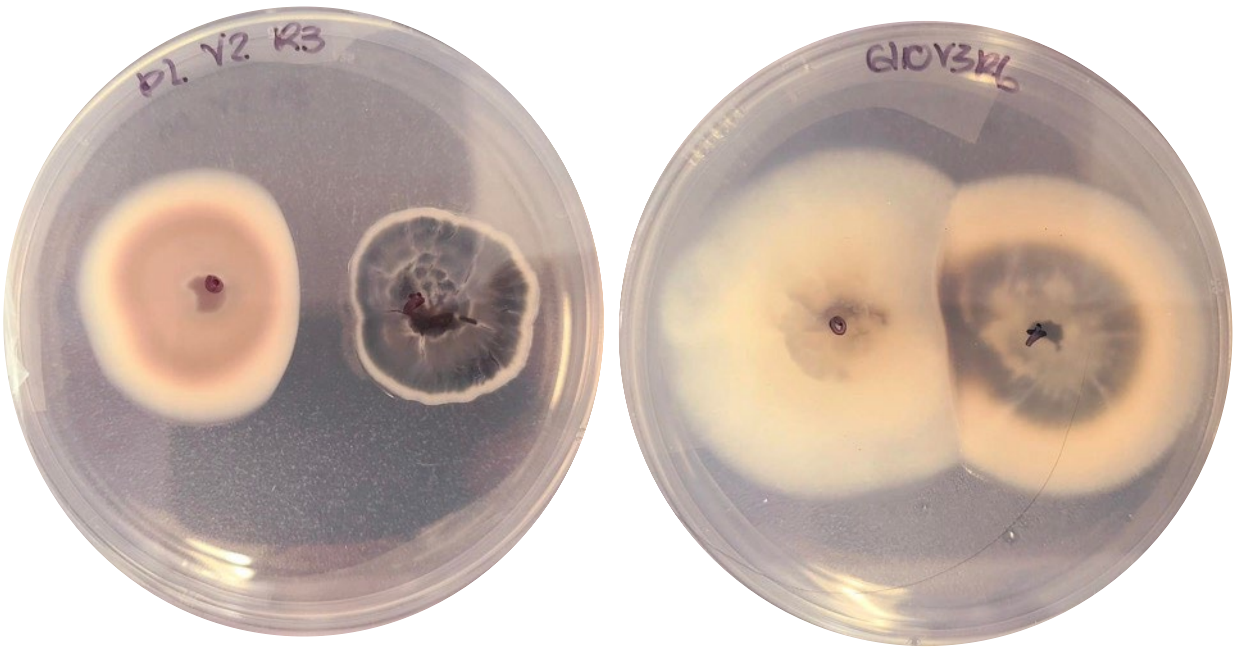


Figure 6. Verticillium growth together with *P. lilacinum* (left) and *G. catenulatum* (right)

On the other hand, the PDA media amended with Elatus showed the highest suppression of Verticillium growth (Figure 7). Verticillium grew only on the disk and not on the PDA media. On the contrary, in the PDA media that was amended with Quadris, Verticillium did grow outside the disk and on the amended PDA (Figure 8)

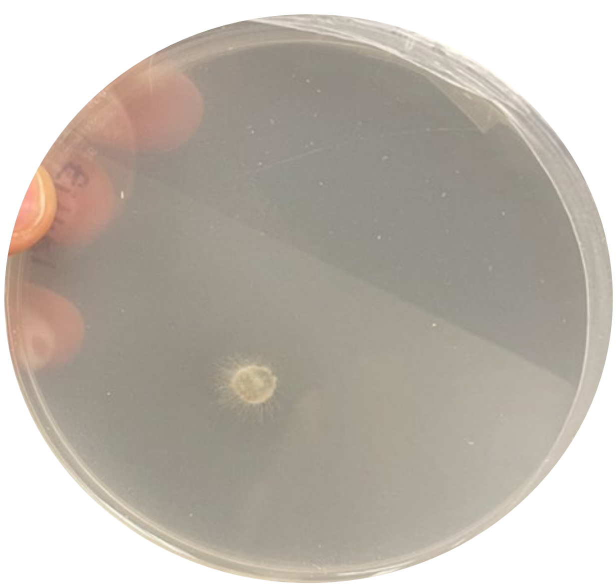


Figure 7. Verticillium growth on PDA media amended with Elatus. Observe grow only on the old disk.

Figure 8. Verticillium growth on PDA media amended with Quadris.

Future Work

The next step of this work is to evaluate the performance of these products under greenhouse conditions

Acknowledgments

We would like to thank the Michigan Potato Industry Commission for funding this project. We would also thank Dr. Jaime Willbur and Mio Sato-Cruz for their huge collaboration and allowing us to conduct these experiments in their lab.

Understanding the benefits of sensor-based irrigation scheduling method in irrigated potato fields

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Introduction

Potatoes benefit from irrigation management because of the significant effect of irrigation on both yield and quality. A shallow root zone combined with daily evapotranspiration makes precise irrigation of potatoes difficult. Not watering the potatoes sufficiently can result in yield loss and cause misshapen tubers, vascular necrosis, or hollow heart defects. Improper irrigation schedules or unnecessary irrigation can waste resources, but can also increase the potential risk of plant diseases. Plant disease can substantially reduce yield and quality of product, and even more importantly impact it during the storage, which are negatively affecting the sustainability and economics of production. Potatoes are impacted significantly by diseases, which can also be driven through increased relative humidity and leaf wetness durations, reduced canopy and soil temperatures, or improper irrigation. Some of the most devastating foliar and vine rotting diseases are early blight, late blight, white mold, and bacterial stem rot or blackleg. In tubers, irrigation has been shown to influence black scurf, silver scurf, and common scab diseases. Excessive soil moisture at critical points can drive foliar, vine, or root and tuber infections and promote pathogen development, reproduction, dispersal, and survival. Proper irrigation management is needed to maximize water use efficiency while minimizing the risk of plant disease. Michigan has experienced more erratic precipitation over the past decades, and the cost of fertilizer and fungicide has been increased. This has led to a demand for technologies to improve water use efficiency and disease management, optimize fertilizer use efficiency, increase crop production and quality, and maximize return on investment. Sensor technology has been utilized in many research projects to improve irrigation management. Demonstration of this sensor technology in irrigated potato fields is needed to evaluate the technology's effectiveness.

Materials and Methods

The project team demonstrated the sensor-based irrigation scheduling method in two commercial potato fields. These fields were in Montcalm and Mecosta County, MI. The irrigation treatments were:

T1: Producer's existing irrigation method
T2: Sensor-based irrigation treatment (Irrigate at 30% Maximum Available-water Deficit (MAD)).

Multiple depths of soil moisture levels, soil temperature, leaf wetness duration, temperature, humidity, and precipitation were observed using sensor technology. Soil samples were collected to test texture, volumetric water content, organic matter, and nutrients. Disease severity and incidence were also monitored for white mold, early blight and early die disease.

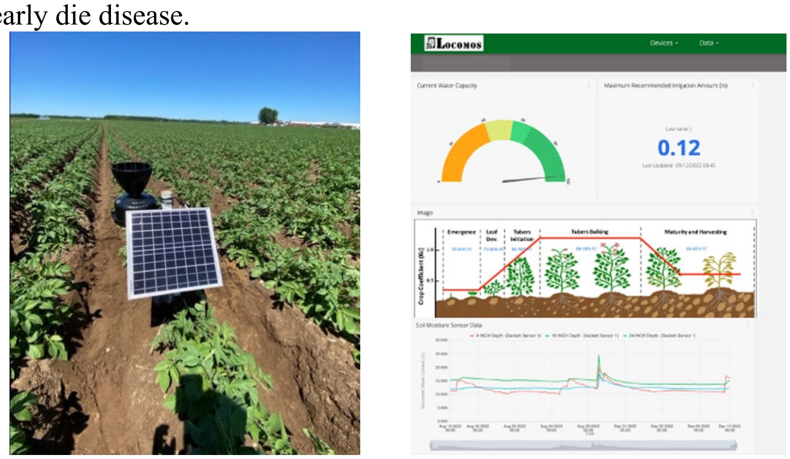

Figure 1. Installed a sensor monitoring system in an irrigation demonstration site in Mecosta County (left), a screenshot of the shared IoT website with the cooperative growers for irrigation management.

Results and Conclusions

Water Management

Soil samples were collected and tested for soil texture, which is the most important parameter in irrigation scheduling. Table 1 shows the soil characteristic of each field at different soil depths. Overall, Field A has sandy loam, and Field B has loamy sand soil. Loamy sand is coarser than sandy loam soil, thus holding less amount of soil moisture. Figures 3 and 4 show the available soil moisture levels of each treatment for each field. Available soil moisture levels in Field B ranged from 1.8 to 2.3 inches, while Field B was between 2.5 and 3.5 inches. Table 2 shows a summary of irrigation, precipitation, and average yields of each treatment for each field. The total irrigation frequency and amount of Field A in both T1 and T2 were the same in the 2022 growing season. The average yields were 449 and 447 cwt/acres for T1 and T2, respectively. In Field B, 1 inch more irrigation was applied to T1 than to T2. The average yields were 426 and 425 cwt/acre for T1 and T2, respectively. The team found that the sensor-based irrigation scheduling saved about 1 inch of application in Field B, while maintaining a similar average yield. Overall, both fields' existing irrigation strategies (timings and amount) were similar to the sensor-based irrigation scheduling.

The average yield of the dry corner in Field B was 192 cwt/acre. Using the dry corner yield data, Water Use Efficiency (WUE) was calculated. WUE (cwt/acre/in) is calculated as the difference in yield between the irrigated land and the dry corner divided by the irrigation amount applied. WUE for T1 and T2 were 28.6 and 33.2 cwt/acre/in. This data shows the justification for irrigation in potato production. In addition, this data shows the potential to improve irrigation water use efficiency using sensor technology, but more fields and years of observations are needed.

Table 1. Soil characteristics in each field at different depths.

Field	Treatment	Soil Depth (in)	Sand (%)	Silt (%)	Clay (%)	Soil Type
Field A	T1	9	79.0	11.4	9.60	Sandy Loam
		18	78.5	11.0	10.5	Sandy Loam
		24	79.5	10.0	10.5	Sandy Loam
	T2	9	77.5	11.9	10.6	Sandy Loam
		18	78.5	10.9	10.6	Sandy Loam
		24	76.5	12.4	11.1	Sandy Loam
Field B	T1	9	82.0	8.90	9.10	Loamy Sand
		18	83.5	7.90	8.60	Loamy Sand
		24	83.0	8.40	8.60	Loamy Sand
	T2	9	80.5	9.90	9.60	Loamy Sand
		18	80.5	9.40	10.1	Loamy Sand
		24	83.5	7.90	8.60	Loamy Sand

Table 2. Precipitation, irrigation, and average yield of each field.

Farm	Treatment	Precipitation (in)	Irrigation Frequency	Irrigation Amount (in)	Avg. Yield (cwt/acre)
Field A	T1	9.63	10	6.44	449
	T2	9.63	10	6.44	447
Field B	T1	12.6	12	8.17	426
	T2	12.6	11	7.02	425
	Dry land	12.6	0	0	192

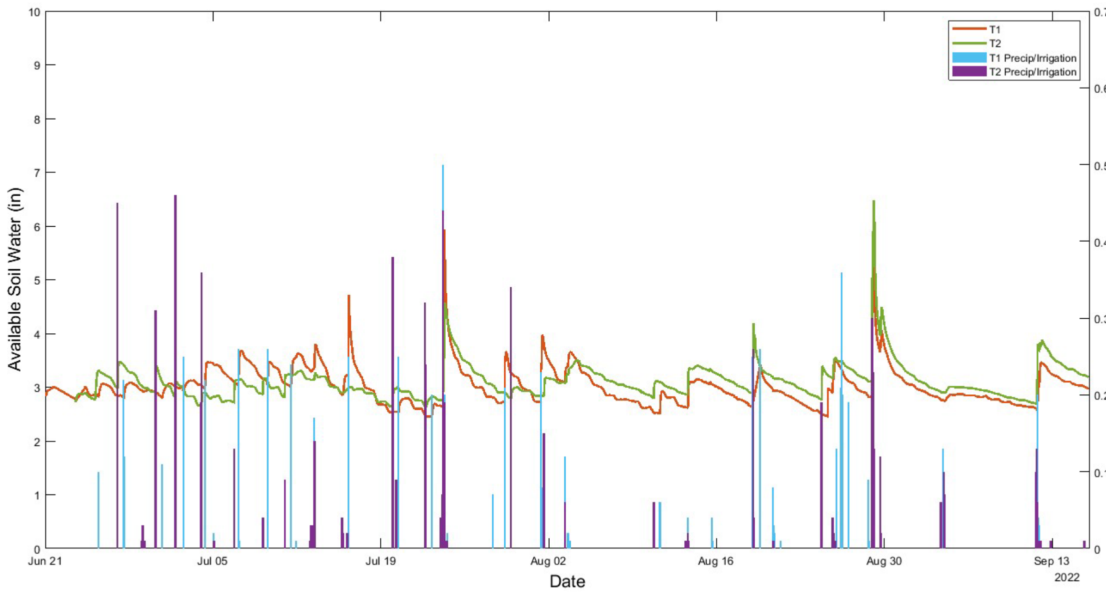

Figure 2. Available Soil Water based on soil moisture sensor data of each treatment in Field A.

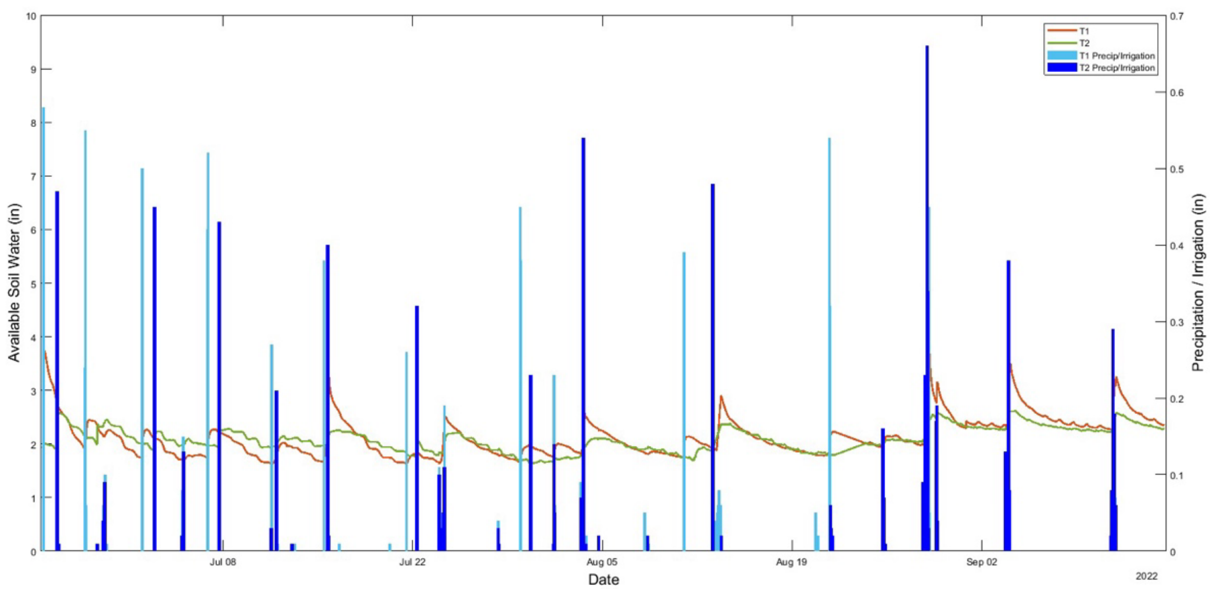

Figure 3. Available Soil Water based on soil moisture sensor data of each treatment in Field B.

Disease Monitoring and Tuber Quality Evaluations

End-of-season foliar disease observations and evaluations of tuber samples from sensor- and grower-based irrigation programs were conducted Sep 9 and Nov 9, respectively. Foliar disease measurements were collected only in Field A. White mold incidence (0-100%) and severity (0-3 scale where 0 is no disease and 3 is girdling leading to vine death) were collected and combined into a disease index (%): incidence (%) x severity (0-3) / maximum severity score (3). Early die index was similarly calculated using the severity scores (0-4 scale where 0 is no disease and 4 is severe necrosis in the upper canopy). At harvest, five replicate tuber samples were collected from each irrigation program. Samples were evaluated for size profile (percentage A or B class), specific gravity, internal defects vascular discoloration and brown spot that could be symptoms associated with soilborne diseases, and blemish diseases common scab and Rhizoctonia black scurf (0-5 scale where 0 is no disease and 5 is greater than 50% tuber surface area impacted). A generalized linear mixed model procedure (SAS v 9.4) was used to conduct all analyses of variance and mean separations at alpha=0.05.

Table 3. End-of-season foliar disease observations collected Sep 9 from (T1) grower- and (T2) sensor-based irrigation programs evaluated at Field A in 2022.

Field	**Trt**	**White Mold Incidence (%)^z**		**White Mold Index (%)**		**Early Blight Incidence (%)**		**Early Blight Severity (%)**		**Early Die Incidence (%)**		**Early Die Index (%)**	
A	T1	32.0	b	20.4	b	97.5		3.3	b	20.7	b	12.6	b
	T2	60.0	a	41.8	a	100		4.6	a	41.4	a	33.2	a
P-value		*<0.001*		*<0.01*		*>0.05*		*<0.05*		*<0.05*		*<0.05*	
LSD		*11.1*		*10.7*		*n.s.*		*1.3*		*18.6*		*17.7*	

^{z} Column values followed by the same letter were not significantly different based on Fisher's Protected LSD (α=0.05).

Table 4. Tuber size profile and quality metrics assessed Nov 9 from samples collected from (T1) grower- and (T2) sensor-based irrigation programs evaluated at Field A and Field B in 2022.

Field	**Trt**	**% A**	**% B**		**Specific Gravity**	**Vascular Discolorat'n (%)**	**Internal Brown Spot (%)**	**Common Scab (0-5)**	**Rhizoctonia Black Scurf (0-5)**
A	T1	93.0	7.0		1.096	8	2	1.2	0.2
	T2	89.0	11.0		1.098	16	0	1.3	0.0
St. Err.		*1.3*	*1.3*		*0.0007*	*5.5*	*1.4*	*0.3*	*0.1*
P-value		*>0.05*	*>0.05*		*>0.05*	*>0.05*	*>0.05*	-	-
LSD		*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	-	-
B	T1	95.4	4.5	a	1.081	10	5	0	-
	T2	97.1	1.2	b	1.084	10	0	0.3	-
St. Err.		*1.4*	*0.6*		*0.0009*	*8.5*	*2*	*0.2*	-
P-value		*>0.05*	*<0.01*		*>0.05*	*>0.05*	*>0.05*	-	-
LSD		*n.s.*	*1.7*		*n.s.*	*n.s.*	*n.s.*	-	-

^{z} Column values followed by the same letter were not significantly different based on Fisher's Protected LSD (α=0.05).

In Field A, significantly greater late-season incidences and indices of white mold ($P < 0.01$) and early die ($P < 0.05$) were observed under the sensor-based irrigation program. Similarly, early blight severity was significantly greater in the sensor-based program. However, minor satellite-level differences in canopy greenness (NDVI) were visible in mid-June, with the field T2 showing slightly more greenness and uniform canopy development. In September, these differences were again visible with the T2 area exhibiting considerably less intense greenness than the T1 area. The more advanced T2 maturity could have led to increased late-season disease pressure or could indicate soil conditions or history that predisposed the area to higher pathogen activity. Furthermore, no consistent differences were detected between irrigation programs based on tuber size profiles, quality metrics, or blemish diseases in samples from Field A and B. Additional field and year disease observations are required.

2022 Potato Research, Outreach and Education Report
George W. Bird, Professor Emeritus
Department of Entomology, Michigan State University

The 2022 potato research, outreach and education initiatives consisted of the following six activities:

- A Michigan potato soil health dynamics (2012-2022) survey funded by the Michigan Potato Industry Commission Research Committee.
- Reassessment of the 2012 potato soil health survey in regards to the impact of soil fumigants on soil health indicators.
- Continued development of thermal stability as a soil health indicator.
- Presentation at the 2022 Annual Meeting of the Potato Association of America.
- Presentation at the 2022 Annual Meeting of the Society of Nematologists.
- Completion of the first draft of a new e-book entitled, Potato Nematodes of North America being written for the J. R. Simplot Company.

A brief statement of proposed plans for 2023 is included at the end of the report.

2012-2022 Michigan Potato Soil Health Dynamics

In 2011, the Michigan Potato Industry identified soil health as a key research topic. This was followed by a soil health workshop and a survey in 2012. The survey consisted of 98 sites on eight commercial potato farms, using the Cornell University Soil Health Laboratory's twelve soil health indicators. The results indicated the soil chemistry was optimal for potato production, while there was a distinct need to improve the physical and biological aspects of the soil

Summary of the results of the 2012 Michigan potato soil health survey of 97 sites.

Sites	Soil Aggregates	Avail. Water	Soil Hardness	Soil OM	Active Carbon	N Minn.	Ext. P	Ext. K	Minor Elements	Score 0-100
Scab Sites	58%	26%	56%	11%	11%	32%	98%	94%	100%	57.6%
Early Die	56%	22%	57%	10%	15%	31%	92%	95%	100%	57.5%
High Yield	58%	26%	58%	10%	8%	47%	100%	98%	97%	58.2%

The 10th anniversary of the survey provided a unique opportunity to study the dynamics of the soil health indicators associated with farms included in the 2012 survey. A research project for the 2022 survey submitted by G. Bird, B. Basso, R. Price and M. Otto was approved by the MPIC Research Committee for $11,765.

The seventeen of the eighteen fields from the six Montcalm/Mescota County potato farms included in the 2012 potato soil health survey were sampled prior to potato planting in 2022. One field was unavailable because of spring soil fumigation. A meeting at each of these farms was held prior to taking the samples to determine what soil heath improvement and nematode management practices had been ued during the past ten years. Using the 2012 geo-positioned reference points, four ten-acre subsamples were obtained from each filed and sent to the Cornell Soil Health Lab. for analysis of four physical, four chemical and four biological soil health indicators. In addition, soil from twenty-four of the sites were sent to Woods End Lab. for soil health analysis.

The results of the 2022 soil health survey using the Cornell University Soil Health Laboratory data indicated that:

- There was a significant positive increase in the soil organic matter associated with all sites.
- There was a significant positive increase in active carbon associated with all sites.
- There was a significant positive increase in soil water holding capacity associated with all sites.
- Population densities of the Penetrans root-lesion nematode were lower in 2022, compared to 2012.
- Nitrogen mineralization potential remained low, but was difficult to access because Cornell University changed the assay for this parameter.
- Soil respiration remained low.
- In most of the sites there was a decline in percent soil water stable aggregates. This change was unexpected and the parameter needs additional investigation in regards to its utility as a soil health indicator.

The study clearly indicated that change in soil health indicators over the ten-year period is a more practical indicator than a single soil health score.

The results Woods End Laboratory were similar to those from the Cornell Soil Health Laboratory. Analyses from the Woods End Laboratory were completed in a timely manner and appeared to be presented in a farm-friendly way. The Cornell data files were excellent for research purposes. Ten years after the Michigan potato industry identified soil health as a key topic, there is still no place in Michigan to send soil samples for a complete soil health analysis. In addition, Michigan State University closed its soil chemistry/physics public service laboratory in 2022.

The on-farm interviews indicated that yield stability, soil health and farm ecosystem quality/sustainability were high priorities. Use of compost and cover crops was common. There was less soil before the 2022 potato crop, compared to the 2012 crop. In some cases, in-row soil fumigation had replaced broadcast soil fumigation.

Assessment of the Impact of Soil Fumigation on Soil Health Indicators

As indicate in the previous table, there were no soil health indicator differences detected in the 2012 survey among the high yielding, scab and potato early-die sites. As a result of additional data mining associated with the 2022 survey it was determined that management practices impacted soil quality. Half of the eighteen fields used in the initial survey had been fumigation the fall before potato planting in the spring of 2012. Acescent of the data for this indicated that:

- Sites fumigated in the fall of 2011 had significantly lower water stable aggregates than non-fumigated sites,
- Sites fumigated in the fall of 2011 had significantly lower active than non-fumigated sites.
- Sites fumigated in the fall of 2011 had significantly lower nitrogen mineralization than no-fumigated sites.

While it may appear that these are negative changes, research has indicated that some of the first microorganisms to recolonize soil following fumigation stimulate potato plants to activate their immune systems, resulting in healthy plants with high tuber yields. This may explain a portion of the benefits of soil fumigation in potato production.

Relationships Among Thermal Stability and Soil Health Indicators

Recent research shows strong relationships between low tuber yields, hot thermal stability and low soil health indicators. The Bruno Basso Laboratory has produced thermal stability maps for as several of the sites included in the 2012 and 2022 soil health indicator surveys. These will be presented and discussed in the 2022 Basso Laboratory Report.

Presentation at the 2022 Annual Meeting of the Potato Association of America

Relationships Among Soil Health Indicators and Potato Field Histories.
George W. Bird[1], Mark Otto[2], Bruno Basso[3] and Richard Price[3], [1]Department of Entomology, Michigan State Univ., E. Lansing, MI, [2]AgriBusiness Consultants. Lansing, MI and [3]Department of Earth and Environmental Sciences, Michigan State Univ., E. Lansing, MI.
In 2011, the Michigan Potato Industry identified soil health as a key topic for research. Subsequently, a soil health survey of three fields from each of eight Michigan potato farms was conducted in 2012. The fields were selected based on their histories of high tuber yields, potato early-die or significant incidence of potato scab. Four ten-acre blocks were sampled in each of the 24 fields in accordance with the Cornell University Soil Health Laboratory (CUSHL) protocol. The samples were processed at CUSHL for four biological, four physical and four chemical soil health indicators. On a scale of 0 to 100, the mean score for the 96 samples was 57.7. Water stable aggregates, nitrogen mineralization potential and active carbon had means of 39.9%, 8.04 µN/dwtsoil/week and 241 ppm, respectively. There were no significant differences among the chemical and physical indicators for the site histories. Nitrogen mineralization was greater in the fields with histories of high tuber yields, compared to the potato early-die or potato scab sites. Carbon mineralization was lower in the high-yielding and early-die sites, compared to the scab sites. In addition, Michigan State University scientists have developed a remote sensing system for thermal stability as a potential soil health indicator. Recent studies exhibited positive relationships between tuber yields and water stable aggregates, nitrogen mineralization potential, active carbon, total CUSHL soil health scores and thermal stability. The 2012 Michigan potato

soil health survey is being repeated in 2022 to determine if there has been any industry-wide change in soil health the past decade.

All indications are that the presentation was very well received and PAA is looking forward to an update about the project in 2023.

Presentation at the 2022 Annual Meeting of the Society of Nematologists.

Relationships among *Pratylenchus penetrans*, soil health indicators and soil fumigation in Michigan potato production. G. W. Bird, Michigan State University. Twelve soil health indicators and *Pratylenchus penetrans* were determined for geo-positioned soil samples taken before potato planting from three fields in each of six Michigan commercial potato farms in 2012. Most of the six farms used a two-year rotation with potato and corn or carrots. Nine of the sixteen fields were fumigated the previous fall. On a scale of 0-100, the mean soil health indicator score was 56.3. The farm with the highest soil health indicator scores used a five-year crop rotation that included two cover crops and five cash crops. Mean *P. penetrans* population densities were 53.3 and 4.7 per 100 cm^3 soil for the non-fumigated and fumigated sites respectively. Water stable aggregates (%), active carbon (ppm) and nitrogen mineralization potential (µgN/gdwsoil/week) were significantly lower in fumigated, compared to non-fumigated fields. In fumigated fields, there was a significant negative relationship between *P. penetrans* and active carbon, the highest *P. penetrans* population densities were associated with relatively high levels of water stable aggregate stability and there was no apparent relationship between *P. penetrans* and nitrogen mineralization potential. The survey was repeated in 2022, using the 2012 geo-referenced soil sampling points to access changes in soil health associated with Michigan's potato industry. In general, *P. penetrans* population densities were lower in 2022, compared to 2012. In addition, there were changes in nematode management including types, rates and placement of nematicides, and modifications in crop rotations.

This was the only presentation at the SON meeting using the Cornell Soil Health Laboratory soil health indicators.

Potato Nematodes of North America

The initial draft of a new e-book entitled, *Potato Nematodes of North America* was completed. It is being written under contract for the J. R. Simplot Company, using the style of the MSU *Field Crop Ecology* publication. The objective is to have it completed for 2023 Annual Meeting of the Potato Association of America. The following is the book's outline.

Potato Nematodes of North America Types, Symptoms and Management

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Program Plans for 2023

- Complete Potato Nematodes of North America.
- Give a presentation at PAA in PEI on potato nematodes of North America.
- Give a presentation at the annual Meeting of the Society of Nematogists on potato nematodes of North America.
- Present the 2012-2022 Michigan Potato Soil Health Survey data to the MPIC Research Committee.
- Write a paper on the impact of soil fumigation on soil health indicators for publication in the American Potato Journal.
- Write a paper with Bruno Basso on thermal stability as a soil health indicator.
- Write a paper, possibly for publication in Science or Nature on the dynamics of soil health associated with Michigan potato production systems.

Evaluation of foliar fungicide timing to manage white mold of potato in Michigan, 2022.

Chris Bloomingdale, Jaime Willbur; Potato and Sugar Beet Pathology Program Dept. Plant, Soil and Microbial Science Michigan State University East Lansing, MI 48824

Montcalm Research Center (MRC): In 2022, a foliar fungicide timing trial was established at MRC in Lakeview, MI and managed by the Potato and Sugar Beet Pathology program. The trial objective was to determine the most effective timing of fungicide applications for managing white mold in potato. A randomized complete block design, with four replicates, was used. Potato seed were cut from US#1 'Lamoka' and an undisclosed white mold susceptible Frito Lay variety tubers and allowed to suberize before planting. The trial was hand-planted 1 Jun. Plots were two rows wide (34-in. row spacing) by 20 ft long and a 10-in seed spacing was used. Standard grower practices were followed to manage non-target pests. Fluazinam applications (8 fl oz/A) were made at full bloom and 14-d post-bloom; treatments of full bloom, post-bloom, and full followed by post-bloom applications were compared to a grower standard control. A CO_2 powered backpack sprayer, equipped with two TJ 8004XR flat fan nozzles and operating at a boom pressure of 38 psi, was used to apply fungicides at 20 gal/A. To control for late blight, weekly chlorothalonil or mancozeb applications were initiated 1 Jul and applied until vine kill. Apothecia data were collected weekly between approximately 5 Jul and 17 Aug. Disease data were collected 17 Aug and 7 and 14 Sep. Ten stems were arbitrarily rated from both rows and assigned a disease severity (0-3). The severity ratings were: 0 = no disease to 3 = infection girdling mainstem, resulting in wilting and/or death. The ratings were used to calculate a percent disease incidence (DI) and average disease severity of symptomatic plants (DS; 0-3). Disease index (DX) was calculated from the following equation: DX = DI x DS/3. The plots were harvested 28 Sep. On 7 Oct, potatoes were washed then graded for size, weight, specific gravity, and internal defects. A generalized linear mixed model procedure was used to conduct the ANOVA and mean separations at α=0.05.

Mean DX values ranged between 34 and 43% at the final rating for the Frito Lay variety (Table 1) and 23 to 35% for Lamoka (Table 2). White mold indices were lower than in 2021. Across both varieties, most treatments resulted in numerically lower DX values by Sep 7 when compared to the grower standard control. In the Lamoka trial, the 14-d post-bloom and two-application programs resulted in significantly lower frequencies of severely symptomatic stems observed Sep 14 ($P < 0.05$). No significant differences in total or marketable yield were observed ($P > 0.05$). In the Frito Lay variety, the greatest yields were observed in the two-application program, whereas Lamoka yields were greatest following the single 14-d post-bloom application. Apothecial observations indicated that inoculum pressure developed later in the season, likely due to the drier than normal early growing season. Apothecia were observed beginning the last week of July and peaked in early August (two to three weeks after full bloom) supporting white mold reductions in programs that included a later 14-d post-bloom application. Flowers continued to be present at low percentages in the Frito Lay variety for several weeks which could have contributed to the higher end-of-season disease indices. Overall, several site-years of observations suggest that, in varieties with longer flowering periods and when apothecia are present, fungicide applications after the full bloom period may offer more effective white mold control.

Table 1. White mold, yield, and marketable yield observations in treatments tested on undisclosed Frito Lay variety in small-plot research at the Montcalm Research Center in Lakeview, MI in 2022.

No.	Treatment, Rate[z], and Timing[y]	DX (%)[x] Aug 17	DX (%) Sep 7	Severe DI (%) Sep 14	Total Yield (CWT/A)	Marketable Yield (CWT/A)
1	Grower standard treated control	20.8	43.3	21.3	376.7	354.7
2	Omega 500F (8 fl oz) full bloom	28.3	40.9	16.5	377.3	349.9
3	Omega 500F (8 fl oz) 14-d post-bloom	13.3	38.3	13.0	367.1	338.1
4	Omega 500F (8 fl oz) full bloom + 14-d post-bloom	20.0	34.4	11.8	388.6	362.7

[z] All rates, unless otherwise specified, are listed as a measure of product per acre, and all tank mixes contained MasterLock at a rate of 0.25 % v/v.

[y] Applications were made on the following dates for Frito Lay variety: full bloom = 14 Jul and 14-d post-bloom = 27 Jul.

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

Table 2. White mold, yield, and marketable yield observations in treatments tested on Lamoka in small-plot research at the Montcalm Research Center in Lakeview, MI in 2022.

No.	Treatment, Rate[z], and Timing[y]	DX (%)[x] Aug 17	DX (%) Sep 7	Severe DI (%) Sep 14	Total Yield (CWT/A)	Marketable Yield (CWT/A)
1[w]	Grower standard treated control	18.4	35.0	17.9 a	451.1	391.2
2	Omega 500F (8 fl oz) full bloom	15.8	27.5	20.4 a	458.6	390.4
3	Omega 500F (8 fl oz) 14-d post-bloom	19.2	32.0	7.1 b	472.0	404.2
4	Omega 500F (8 fl oz) full bloom + 14-d post-bloom	12.5	23.3	7.5 b	442.1	391.8

[z] All rates, unless otherwise specified, are listed as a measure of product per acre, and all tank mixes contained MasterLock at a rate of 0.25 % v/v.

[y] Applications were made on the following dates for Lamoka: full bloom = 21 Jul and 14-d post-bloom = 4 Aug.

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

[w] Treated control.

Assessment of postharvest SaniDate application and variety resistance for management of storage diseases of potato in Michigan, 2022

Emma Schlachter, Celeste Dmytryszyn, Mio Satoh-Cruz, Chris Bloomingdale, Damen Kurzer, Katrina VanAtta, David Douches, Ray Hammerschmidt, Chris Long, Sarah Ruth, and Jaime F. Willbur; Department of Plant, Soil and Microbial Sciences

Managing disease during the postharvest storage of tubers is important for Michigan's potato industry, due to the year-round demand for potato seed and products. SaniDate 5.0 (active ingredient peroxyacetic acid: $C_2H_4O_3$) is a disinfectant used in food and water industries, which breaks down into harmless residual oxygen and hydrogen, unlike many conventional pesticides. Over two years, SaniDate 5.0 was evaluated for in-storage control of the four major postharvest diseases: Fusarium dry rot, bacterial soft rot, pink rot, and Pythium leak. Developing cultivars with genetic resistance to disease is another effective management strategy; thus, chipping, red, and yellow research lines and germplasm were assessed for resistance response to four postharvest diseases. Promising cultivars will be selected for further development based on these findings, as well as other superior traits.

Materials and Methods

i. Assessment of SaniDate 5.0 on storage management disease of four diseases

During 2020 – 2021, efficacy of SaniDate 5.0) application in storage bins for control of four diseases was assessed. This study was performed at the MPIC Cargill Potato Demonstrations Storage Facility (95% relative humidity, 48°F). Potato tubers cv. Mackinaw were mechanically harvested and separated into plastic mesh bags (10/replicate/treatment; 800 tubers). Tubers were washed in tap water twice in mesh baskets, surface disinfested in bleach solution (10% Clorox Bleach, 90% tap water) for 30 seconds, and rinsed once in deionized water, before air-drying overnight in ambient room conditions. Tubers were inoculated with the following treatments: Fusarium dry rot, bacterial soft rot, pink rot, Pythium leak, and potato dextrose broth (control). *Fusarium sambucinum*, *Phytophthora erythroseptica*, and *Pythium ultimum* were inoculated at 2×10^4 spores/mL in potato dextrose broth. *Pectobacterium caratovorum* was inoculated at 8×10^8 cfu/mL. Inoculation using 10uL of each solution was performed no more than three hours after inoculum preparation using Hamilton® syringe (710 series, 100uL volume) at apical and basal ends of each tuber. Tubers were undisturbed for 24 hours prior to organization to prevent leakage, and then organized into four replicates within plastic mesh bags.

Two days after inoculation, samples were placed into tuber piles of Bin 8 (control) and Bin 9 (treatment) during loading at approximately 4-foot increments. Bin 9 was treated post-loading with SaniDate 5.0 at 0.95 fl. oz. per ton of potatoes by fog application (Gun Valley Ag. & Industrial Services, Inc.). After the storage period, bins were emptied, and samples were collected. In 2020, bins were loaded on Oct 14, SaniDate 5.0 was applied on Oct 19, and bins were emptied on Jun 24, 2021. In 2021, bins were loaded on Oct 16, SaniDate 5.0 was applied on Nov 24, and bins were emptied on Jul 6, 2022. Tubers were evaluated for internal and external disease and internal symptom length and width were measured using digital calipers. Analysis of variance (ANOVA) was conducted using the generalized linear mixed model (GLIMMIX), evaluating fixed effects inoculation treatment, SaniDate treatment, and interaction, defining replicate as random effect. Years were analyzed separately due to difference in inoculation treatment and protocol.

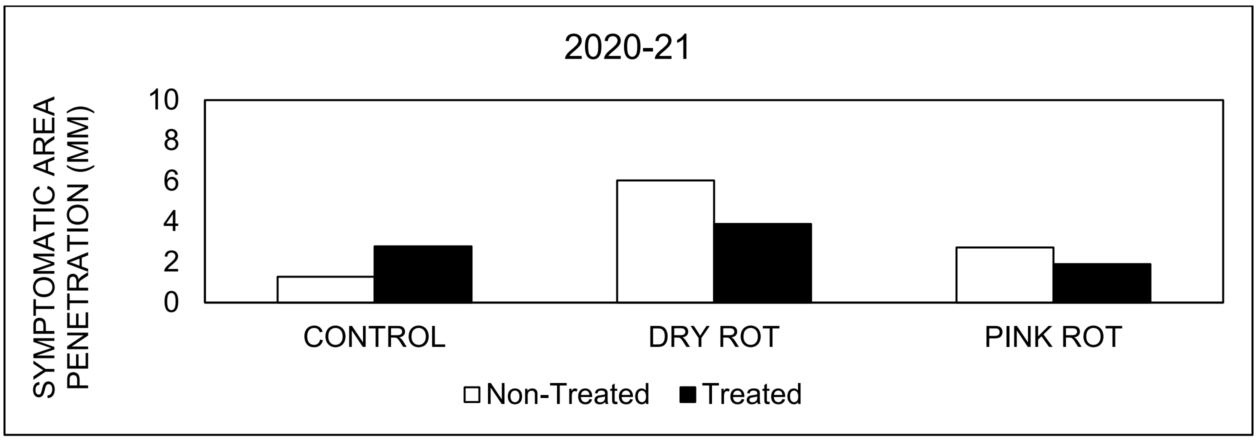
ii. Assessment of chipping and red and yellow potato varieties and early-stage germplasm for resistant to four storage pathogens

During 2021-2022, 35 commercial chip varieties and research germplasm were assessed for resistance response to four diseases, and in 2022, 15 red and yellow varieties were also assessed. Asymptomatic tubers were obtained from Michigan commercial growers, the Michigan Potato Outreach Program, and the Potatoes USA-SNAC International Trial (Kalkaska County) (2-6 tubers/replicate/year). Inoculation was performed as described above. Tubers were placed in paper bags at ambient room temperatures for 47 days, and internal symptom length and width was measured using digital calipers. Analysis of variance (ANOVA) was conducted using the generalized linear mixed model (GLIMMIX), evaluating inoculum treatment, variety, and interaction. Data was analyzed using the GLIMMIX procedure in SAS v. 9.4 and means were compared using Fisher's protected LSD (α=0.05).

Results and Conclusions

i. Assessment of SaniDate 5.0 on storage management disease of four diseases

In 2020-21 and 2021-22, SaniDate 5.0 treatment did not significantly affect disease symptom length, width, or penetration ($P > 0.05$). In both years, greater Fusarium dry rot development was observed compared to bacterial soft rot, pink rot, or Pythium leak ($P < 0.05$).



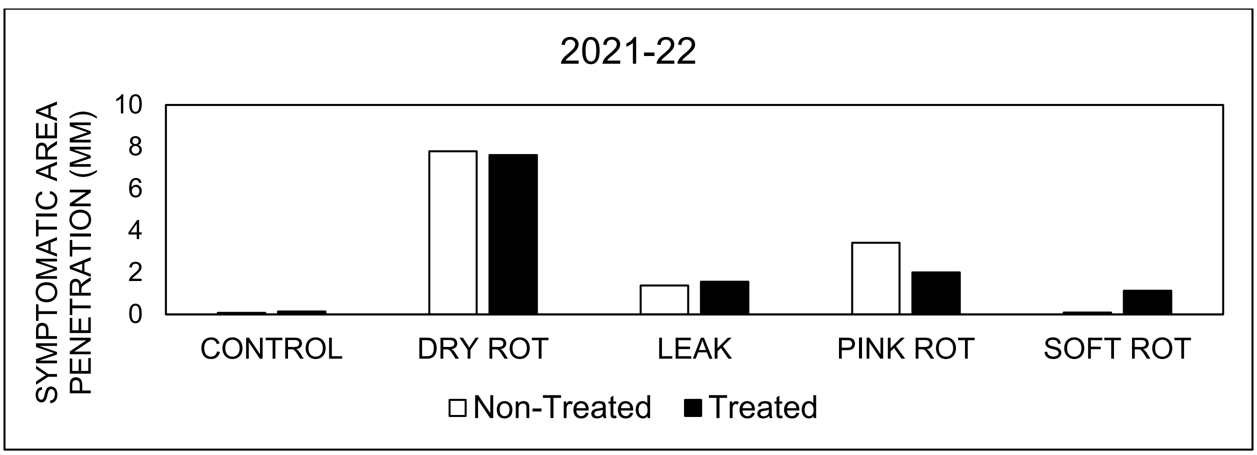


Figure 1. Mean symptomatic area measured on tubers approximately seven months post-inoculation with 2 x 10^4 spores/mL *Fusarium sambucinum*, *Pythium ultimum,* or *Phytophthora erythroseptica* or 8 x 10^8 cfu/mL *Pectobacterium carotovorum*. Each bar represents four replicates of 10-tuber subsamples. SaniDate 5.0 did not significantly affect disease development in 2020-21 or 2021-22 (α = 0.05).

ii. Assessment of chipping and red and yellow potato varieties and early-stage germplasm for resistant to four storage pathogens

Significant variation in Fusarium dry rot resistance response was observed in red and yellow tubers during 2020-21 (Table 1). In chip entries, consistent resistance to dry rot was observed in both years in the chipping research lines MSAA260-3, MSAA570-3, and MSBB058-1 (Table 2). Identifying germplasm with superior disease tolerance will benefit the development of cultivars with excellent processing and storage qualities.

Table 1. Significant variation between Fusarium dry rot symptom development was observed in red and yellow entries in disease response evaluations in 2021-22 ($\alpha = 0.05$). Red-skinned lines are indicated by an asterisk (*) and standard commercial varieties are indicated in bold text. Resistance ratings are based on the highest mean observed in the year sample (S = susceptible [within 75-100% of the greatest mean]; MS = moderately susceptible [50-75%]; MR = moderately resistant [25-50%]; R = resistant [0-25%]). Blue highlighted varieties exhibited MR to R reactions across one to three locations.

	2021-22		
	Fusarium Dry Rot Length (mm)		
Entry	**Mean**	**Group**	**R/S**
***Dark Red Norland**	**5.5**	**c**	**R**
C099076-6R	6.2	bc	R
Yukon Gold	**11.4**	**bc**	**MR**
*NDA050R37B-1R	11.8	bc	MR
Paroli	12.1	bc	MR
Gourmandine	15.2	bc	MR
MSV093-1Y	15.3	bc	MR
*NDAF113484B-1	17.7	bc	MR
Queen Anne	18.5	bc	MR
Allora	18.5	b	MR
Golden Globe	24.2	ab	MS
Constance	25.8	ab	MS
Columba	27.4	ab	MS
W15240-2Y	40.8	a	S
P-value	*P < 0.05*		

Overall Summary

Over two years, experimental methods were developed and tested for screening of postharvest management practices and disease resistance in chipping, red, and yellow potato entries using Michigan pathogen isolates. Resistant reactions were identified for Fusarium dry rot and pink rot. Variable reactions were often influenced by year, location, and growing conditions and resistance to multiple diseases was rarely observed. However, ongoing screening will help to inform growing operations, management practices, and breeding efforts. Further optimized experimental protocols were implemented in 2022-23.

Acknowledgements

We would like to thank the grower cooperators and key industry representatives who participated in this survey, our fellow researchers and undergraduate research assistants in the Potato and Sugar Beet Pathology and USDA-ARS Sugar Beet Pathology programs, the Potato Outreach Program, the Montcalm Research Center, the Michigan Potato Industry Commission, MSU AgBioResearch, and the MSU RTSF Genomics Core for their continued support of our research. Funding also provided by the MDARD Specialty Crop Block Grant #210000000484.

Table 2. Significant variation between Fusarium dry rot symptom development was observed in chipping line research germplasm disease response evaluations in 2020-21 and 2021-22 ($\alpha = 0.05$). Standard commercial lines are indicated in bold text. Resistance ratings are based on the highest mean observed in the year sample (see Table 1 description). Blue highlighted varieties exhibited resistant to MR to R reactions over two site-years of testing.

		Fusarium Dry Rot Symptom Length (mm)					
		2020-21			2021-22		
Entry	**Location**	**Mean**	**Letters**	**Rating**	**Mean**	**Letters**	**Rating**
MSAA570-3	B	5.1	g	R	6.0	d	R
NY163 (B)	B	6.7	f-g	R	9.1	d	MR
MSZ063-2 (B)	B	7.9	fg	R	.	.	.
Snowden (A)	**A**	**8.0**	**fg**	**R**	**.**	**.**	**.**
MSW474-1 (B)	B	8.1	fg	R	19.1	a-d	S
MSZ242-13 (B)	B	8.4	fg	R	12.6	a-b	MS
Petoskey (B)	**B**	**8.4**	**e-g**	**R**	**11.9**	**a-d**	**MR**
ND7519-1	B	8.7	e-g	R	.	.	.
MSZ063-2 (A)	A	8.7	e-g	R	.	.	.
Mackinaw (B)	**B**	**9.2**	**e-g**	**R**	**.**	**.**	**.**
Snowden (B)	**B**	**9.2**	**e-g**	**R**	**6.1**	**b-d**	**MR**
MSAA076-6	B	9.6	d-g	R	.	.	.
MSBB058-1	B	9.9	e-g	R	7.2	b-d	MR
MSY156-2	B	10.0	e-g	R	.	.	.
Lamoka	**B**	**10.2**	**d-f**	**R**	**.**	**.**	**.**
MSZ242-07	B	10.6	e-g	R	16.5	a-b	MS
MSAFB635-3	B	11.4	e-g	R	.	.	.
NY166	B	11.7	e-g	R	.	.	.
MSBB610-13	B	13.0	e-g	MR	.	.	.
MSZ242-13 (A)	A	13.8	d-g	MR	.	.	.
CO11023-9W	B	14.3	d-g	MR	.	.	.
MSW474-1 (A)	A	15.6	d-g	MR	.	.	.
MSAFB609-12	B	15.9	d-g	MR	15.4	a-c	MS
MSAFB635-15	B	16.9	d-g	MR	24.4	a-d	S
NY165	B	20.0	d-g	MR	.	.	.
MSZ120-4	B	20.0	d-g	MR	.	.	.
MSAA260-3	B	20.6	d-g	MR	11.3	a-d	MR
B2869-29	B	20.7	d-g	MR	.	.	.
NY163 (A)	A	20.9	d-g	MR	.	.	.
Lady Liberty	**B**	**22.0**	**d-f**	**MR**	**.**	**.**	**.**
MSZ242-09	B	23.1	d-g	MR	.	.	.
Mackinaw (A)	**A**	**26.2**	**b-e**	**MS**	**.**	**.**	**.**
NYOR14Q9-9	B	27.5	b-e	MS	.	.	.
MSAA373-3	B	28.1	b-e	MS	.	.	.
MSAA217-3	B	29.9	b-d	MS	10.8	a-d	MR
MSAFB605-4	B	38.8	a-c	S	.	.	.
MSZ219-13	B	38.9	ab	S	.	.	.
Petoskey (A)	**A**	**40.5**	**a**	**S**	**.**	**.**	**.**
CO11023-2W	B	50.8	a-c	S	.	.	.
MSV093-1Y	B	.	.	.	19.2	a-b	S
P-value		*P = 0.0002*			*P = 0.0415*		

Diagnostic optimization of viral detection and characterization of Potato virus Y for the Michigan seed potato certification program, 2022

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Potato virus Y (PVY) is a major concern throughout the US, including the North Central region, and is one of the primary diseases monitored and tested for in the seed certification process. The MSU Potato and Sugar Beet Pathology (PSBP) program continues to work with the Michigan Department of Agriculture and Michigan Seed Potato Association seed inspectors to: 1) investigate improved detection options to identify accurate, timely, and cost-effective methods for use in Michigan seed potato certification, 2) monitor PVY strain prevalence in Michigan seed potatoes, and 3) investigate PVY strain by chipping potato variety responses.

Materials & Methods:
Tuber testing methods, which do not require breaking tuber dormancy to sample sprouts or plantlets, were used. General (Mackenzie et al. 2015) and multiplex (Lorenzen et al. 2006, 2010; Chikh-Ali et al. 2013) reverse-transcriptase (RT) high-fidelity polymerase chain reaction (PCR) protocols will be compared to existing plantlet assays involving enzyme-linked immunosorbent assay (ELISA) to validate. In 2022, we selected six seed lots for validation of dormant tuber methods. Samples of 200 tubers were taken from each seed lot. Each variety was sampled from two lots where visual PVY was either present or absent in summer field inspections (Table 1). Dormant tuber RT-PCR testing was conducted on all tubers in 10-tuber subsamples. After treatment with Rindite to break dormancy, subsamples were planted and grown out for standard leaflet ELISA. Subsets of positive samples (from research and commercial testing) will be subject to PVY strain confirmation by RT-PCR.

We also conducted growth chamber assays using characterized PVY strains with elite potato germplasm using previously reported methods by Gundersen et al. (2019). Based on our assessment of PVY strain populations in Michigan, we have selected four characterized strains (N:Wi, NTN, N:O, O) and obtained them from collaborators at the University of Idaho. Six varieties were selected for preliminary experiments: Snowden, Lamoka, Mackinaw, Lady Liberty, Petoskey and MSZ242-13. These entries represent current chip varieties used in Michigan and elite experimental varieties originating from the MSU Potato Breeding and Genetics program.

Results & Conclusions:
In 2022, dormant tuber methods identified higher levels of PVY than estimated from the summer field inspections in selected research lots, however, absence and presence of virus observed was equivalent between methods (Table 1). This could be due to in-field spread, varietal expression, strain differences, or variety by strain interactions. Currently, we are repeating validation experiments to verify agreement between dormant tuber and standard grow out methods.

Table 1. RT-PCR results from seed lots assessed for PVY incidence based on summer field inspections. Results are based on positive PVY detections (%) using dormant tuber methods in 2022 (N=number of 10-tuber subsamples tested).

Variety	Typical Symptom Expression	N	Visual Summer (Jun-Jul)	Present (+) Absent (-) (Jun-Jul)	Dormant Tuber RT-PCR (Oct-Nov)	Leaflet ELISA Greenhouse (Jan)
A	Unreliable	20	0.04	+	6.70	*In progress*
A	Unreliable	20	0.00	-	0.00	*In progress*
B	Unreliable	20	0.20	+	14.87	*In progress*
B	Unreliable	20	0.00	-	0.00	*In progress*
C	Reliable	20	0.76	+	9.97	*In progress*
C	Reliable	20	0.00	-	0.00	*In progress*

We continued to assess the strain types prevalent in Michigan seed growing regions (N = approx**.** 7,150 tubers tested in 2022-23). In 2022-23 dormant tuber tests, three major PVY strains were detected, and strain O was not observed this year. Observations from the past three years suggest that $PVY^{N\text{-}Wi}$ remains most prevalent, however, PVY^{NTN}, $PVY^{N:O}$ and PVY^{E} continue to be detected. Strains NTN and E are tuber necrotic strains, and their frequencies must be closely monitored to best inform the seed potato industry of potential risks. We also detected one case of Tobacco rattle virus (TRV) from variety trials samples during field season.

In preliminary experiments, potato variety responses of daughter plants were measured after mechanical infection of mother plants with four PVY strains. We observed mild to severe foliar symptom depending on strain and variety. Across varieties, reductions in total tuber weight relative to the mock-inoculated control were observed for all PVY strains and greatest (mean of 20% reduction) in plants infected with strain NTN (Figure 1). Growth chamber space and conditions limited the quality and number of plants assessed and will require further optimization and repeated experiments. Dormant tuber tests of daughter tubers showed average 91.7% (range of 85.7 to 100%) of tubers originating from PVY-infected mother plants were infected with virus except resistant varieties, Mackinaw and Lady Liberty, where no detectable levels of virus were observed in daughter tubers.

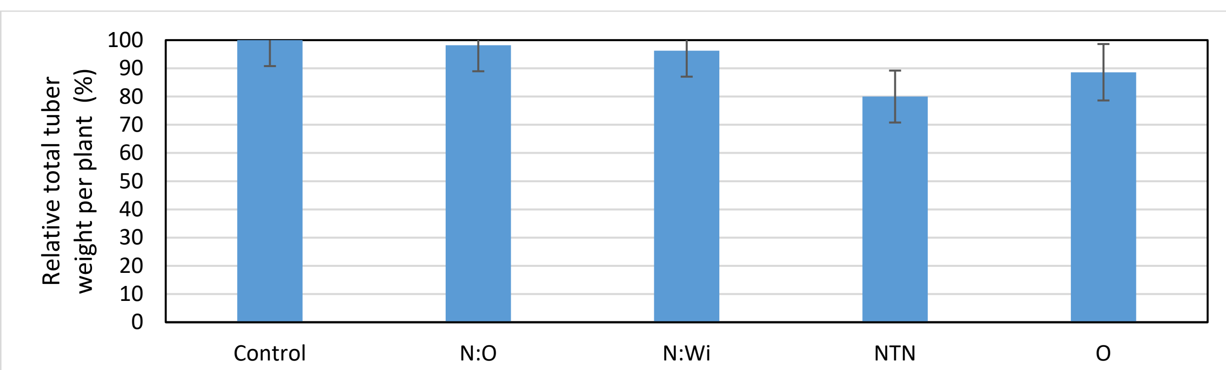

Figure 1. Total tuber weight per plant for mechanically-inoculated first-generation mother plants infected with PVY strains N:O, N:Wi, NTN, and O relative to the mock-inoculated control. Means across six chip potato varieties: Lady Liberty, Lamoka, Mackinaw, MSZ242-13, Petoskey, and Snowden. Bars represent two preliminary replicate plants and error bars represent standard error.

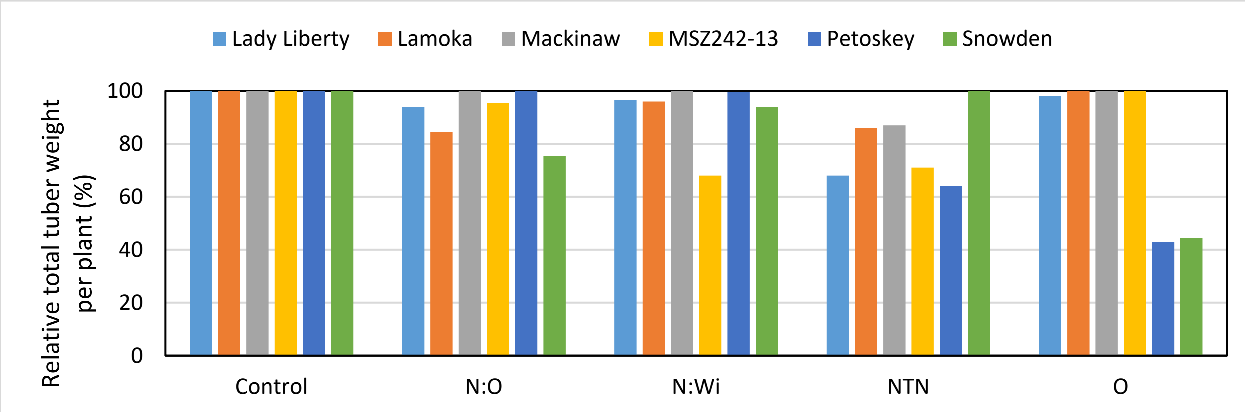

Figure 2. Total tuber weight per plant of mechanically-inoculated first-generation mother plants infected with PVY strains N:O, N:Wi, NTN, and O relative to the mock-inoculated control. Means shown for six chip potato varieties: Lady Liberty, Lamoka, Mackinaw, MSZ242-13, Petoskey, and Snowden. Bars represent two preliminary replicate plants.

In preliminary experiments, yield of some varieties appear generally less impacted by PVY infection of mother plants, such as Mackinaw, while others appear more sensitive to certain strains such as MSZ242-13 to strains N:Wi and NTN, Petoskey to strains NTN and O, and Snowden to strain O (Figure 2). Second-generation observations indicate infected Lamoka and Snowden seed resulted moderate to severe foliar symptoms for strains O and N:Wi whereas Mackinaw showed minimal symptoms (Figure 3, next page). Strain by variety experiments will inform the seed potato industry of the yield and quality impacts that current PVY strains may have on prevalent chip varieties. We will repeat and plan to increase the number of varieties and modify the strain panels used based on current growing practices and strain population assessments. This information will also confirm robust PVY resistance to multiple strains, further informing and directing future breeding efforts.

Overall Summary:

Dormant tuber methods continue to agree with relative absence and presence observations made in summer field inspections and offer an option for seed certification testing where results are available 3-4 months sooner than the typical winter grow out. Final validation experiments are in progress. Coordination between MSU, MDARD, and MSPA has enabled regular monitoring of Michigan PVY strains and indicate strain N-Wi remains most prevalent, however, tuber necrotic strains NTN and E, and other tuber necrotic viruses, require further monitoring. Furthermore, preliminary results of variety by strain screening efforts suggest tuber yield impacts and foliar symptoms may be observed in seed infected with common Michigan strains.

Acknowledgements:
We would like to thank the Michigan potato growers, the Michigan Potato Industry Commission, the Michigan Seed Potato Association, the Michigan Department of Agriculture and Rural Development, as well as the UDSA-NIFA-SCRI Grant No. 2020-51181-32136 and national Potato Virus Initiative: Developing Solutions for the continued support and productive collaborations necessary to continue this research.

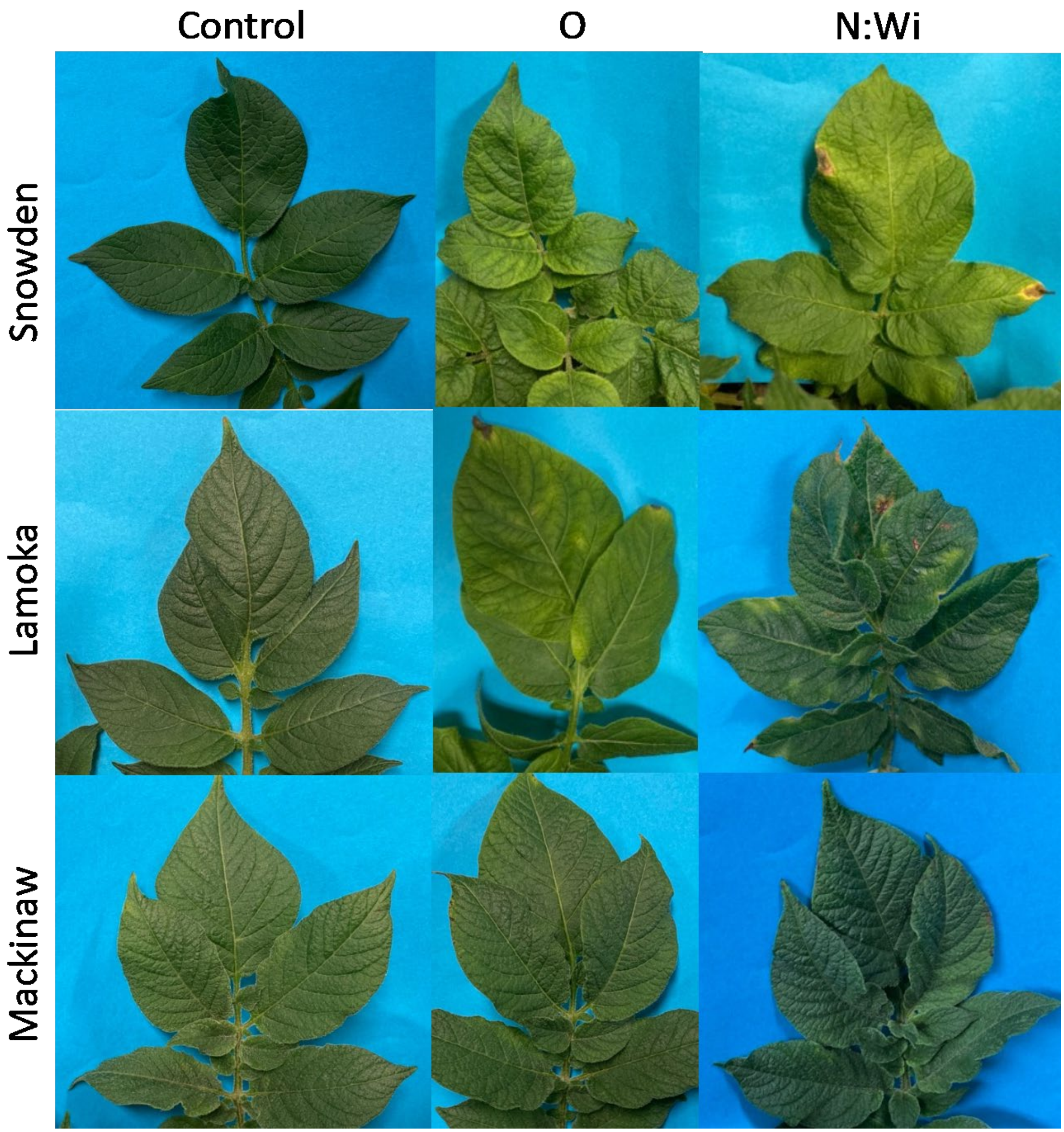

Figure 3. Foliar symptom images from second-generation daughter plants following grow out from mechanically-inoculated first-generation mother plants infected with PVY strains O, N:Wi and mock-inoculated control. Three potato varieties: Snowden, Lamoka and Mackinaw. Images are not scaled.

POTATO (*Solanum tuberosum* 'Lamoka')
Rhizoctonia canker and black scurf; *Rhizoctonia solani*

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Evaluation of seed treatments and in-furrow and banded fungicides to manage Rhizoctonia canker and black scurf of potato in Michigan, 2022.

Experimental and commercially available fungicides were tested to determine their efficacy in managing Rhizoctonia canker and black scurf. A field trial was established at the Montcalm Research Center in Stanton, MI. A randomized complete block design was used, and treatments were replicated four times. Soil type is a loamy sand. US#1 'Lamoka' potatoes were cut into 2-oz seed pieces and left to suberize. Once suberized, seed treatments were applied to tubers on 2 Jun using a cement mixer. The trial was hand planted 3 Jun, using 2 row (34-in row spacing) by 20 ft long plots seeded at 1.2 seed/row-ft. Before closing rows, *Rhizoctonia*-infested barley was placed in-furrow at 7.5 g/row-ft, and in-furrow fungicides were applied. A CO_2-powered backpack sprayer, equipped with TJ4002E nozzles, was used to apply fungicides in-furrow at 10.5 gal/A (40 psi). Banded applications were applied at hilling (14 Jul), using the previously mentioned CO_2 sprayer. Stand establishment was monitored through the growing season and stem canker disease ratings were collected mid-August. Plots were harvested 28 Sep and later graded. Final stem counts, stem canker index, black scurf incidence, and yield were compared among treatments. A generalized linear mixed model procedure was used to conduct the ANOVA and mean separations at the α=0.05 significance level (SAS version 9.4).

Significant Rhizoctonia stem canker pressure and low black scurf pressure was observed uniformly throughout the trial. Significant differences were observed stem counts ($P < 0.0001$). Significant differences were observed in the stem canker index when using a lognormal distribution of means ($P = 0.05$). Programs 7 and 12 had significantly lower stem canker index values than the inoculated control, however, no difference was observed among black scurf incidence of programs. Finally, significant differences were observed among program total yield ($P < 0.0001$) and marketable yield values ($P < 0.0001$).

No.	Treatment, Rate, and Timing[z]	Stem Count[y]	Stem Canker Index (%)	Stem Canker Index[x] (lognormal)	Black Scurf Incidence (%)	Total Yield (cwt/A)	Marketable Yield (cwt/A)
1	Non-treated, inoculated control	38.8 b	25.9	3.1 ab	0.06	169.7 b	155.4 b
16	Non-treated, non-inoculated control	64.8 a	-	-	0.05	292.0 a	262.9 a
2	Moncoat ST (0.51 fl oz/cwt) A	39.3 b	25.6	2.9 a-c	0.06	193.5 b	174.1 b
3	Proline (0.25 fl oz/cwt) A	9.5 c	22.0	2.9 a-c	0.04	82.8 c	80.1 c
4	Moncoat ST (0.51 fl oz/cwt) A; Proline (0.25 fl oz/cwt) A	5.3 c	25.1	3.0 a-c	0.00	65.4 c	63.0 c
5	Moncoat ST (0.38 fl oz/cwt) A; Proline (0.1875 fl oz/cwt) A	4.5 c	21.2	2.4 a-d	0.00	54.5 c	51.5 c
6	Vibrance Ultra Potato (0.5 fl oz/cwt) A	39.8 b	24.7	3.2 ab	0.03	174.5 b	155.9 b
7	Double Nickel LC (8 fl oz/A) B; Double Nickel LC (8 fl oz/A) C	43.8 ab	4.8	1.3 d	0.11	197.6 b	174.4 b
8	Double Nickel LC (16 fl oz/A) B; Double Nickel LC (16 fl oz/A) C	51.5 ab	19.4	2.5 a-d	0.06	215.6 ab	190.9 ab
9	Double Nickel LC (8 fl oz/A) B; Elatus (7.7 oz/A) B	33.8 b	19.1	1.9 bc	0.00	180.9 b	163.5 b
10	Elatus (7.7 oz/A) B	50.3 ab	34.6	3.5 a	0.05	208.1 b	192.3 ab
11	Velum Prime (6.5 fl oz/A) B	41.3 b	30.2	3.1 ab	0.18	210.7 ab	189.1 ab
12	Exp[w] (13 fl oz/A) B	39.0 b	7.0	1.7 cd	0.03	225.5 ab	206.5 ab
13	Elatus (6.4 oz/A) B	42.0 b	9.4	1.9 b-d	0.04	212.3 ab	191.0 ab
14	Quadris (5.3 fl oz/A) B	47.3 ab	24.1	3.2 ab	0.16	249.8 ab	228.2 ab
15	Velum Prime (6.5 fl oz/A) B; Elatus (6.5 oz/A) B	41.3 b	16.7	2.6 a-d	0.01	200.0 b	182.4 b

[z] Application letters code for the following dates: A (seed treatment)=2 Jun, B=3 Jul (in-furrow at plant), C=14 Jul (at hilling).
[y] Column values followed by the same letter were not significantly different based on Fisher's Protected LSD (α=0.05).
[x] Stem canker index analyzed using a lognormal distribution of means.
[w] Exp=Experimental compound.

POTATO (*Solanum tuberosum* 'Lamoka')
Late Blight; *Phytophthora infestans*

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Evaluation of foliar fungicides to manage late blight of potato in Michigan, 2022

Commercially available and experimental fungicides were tested to compare their efficacy in managing potato late blight. A field trial was established at the Michigan State University Plant Pathology Farm in East Lansing, MI. A randomized complete block design, with four replicates, was used. US#1 'Lamoka' potatoes were cut into 2-oz seed pieces and left to suberize before planting. The trial was hand planted 11 Jul. Plots were four rows wide (34-in row spacing) by 20 ft long, and seeded at 1.2 seed/row-ft. All insect, weed, and fertility management was consistent with standard approaches for commercial growers in the region. Foliar fungicide programs were initiated on 9 Sep with follow-up applications made weekly until 3 Oct. A CO_2 powered backpack sprayer, equipped with two TJ 8004XR nozzle, was used to apply fungicides at 20 gal/A (38 PSI). The trial was inoculated 12 Sep after sunset. *P. infestans* inoculum (8×10^3 sporangia/mL) was applied over plots at 20 gal/A using the previously mentioned equipment. After inoculating the trial, a misting system was used to maintain leaf wetness and facilitate disease development. Stand counts were collected at emergence. Foliar disease incidence (DI) and disease severity (DS) ratings (0-100%) were collected regularly for each plot from 26 Aug to 3 Oct. The center two rows of plots were harvested on 9 Nov and graded 11 Nov. The final late blight DI and DS as well as estimated yield and marketable yield (cwt/A) were compared among treatments. A generalized linear mixed model procedure was used to conduct the ANOVA and mean separations (α=0.05).

Differences were observed among the DI ($P < 0.0001$) and DS ($P < 0.0001$) values of programs. All treated programs had significantly lower DI and DS values than the non-treated control but did not differ from each other. Significant differences were observed among total yield ($P < 0.01$) and marketable yield ($P < 0.01$) values.

No.	Product, Rate[z], Timing[y]	Late Blight Incidence (%) Oct 3[x]		Late Blight Severity (%) Oct 3		Total Yield (CWT/A)		Marketable Yield (CWT/A)	
1	Non-treated control	42.5	a	33.8	a	252	a	224	a
2	Bravo Weather Stik (1.5 PT/A) ABCDE	0.0	b	0.0	b	246	ab	224	a
3	Exp[w] (13.7 FL OZ/A) ABD; Reason (5.5 FL OZ/A) AB; Bravo Weather Stik (1.5 PT/A) CDE	0.0	b	0.0	b	184	c	161	b
4	Orondis Ultra (8 FL OZ/A) ABD; Bravo Weather Stik (1.5 PT/A) CE	0.0	b	0.0	b	210	bc	192	ab

[z] All rates are listed as a measure of product per acre, and all foliar applications contained MasterLock at a rate of 0.25 % v/v.

[y] Application timings: A=Sep 9, B=Sep 14, C=Sep 20, D=Sep 27, E=Oct 3.

[x] Column values followed by the same letter are not significantly different based on Fisher's Protected LSD (α=0.05).

[w] Exp=Experimental Compound.

POTATO (*Solanum tuberosum* 'Lamoka')
Pythium Leak; *Pythium ultimum*

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Evaluation of in-furrow fungicides to manage Pythium leak of potato in Michigan, 2022.

A field trial was established at the Montcalm Research Center in Stanton, MI to test the efficacy of in-furrow fungicides for managing Pythium leak of potato. A randomized complete block design was used, and treatments were replicated four times. US#1 'Lamoka' potatoes were cut into 2-oz seed pieces and left to suberize. The trial was hand-planted 3 Jun in loamy sand soil. Plots were two rows wide (34-in row spacing) by 20 ft long and seeded at 1.2 seed/row-ft. Inoculations and in-furrow applications were made before closing furrows. Plots were inoculated with a wet millet and rye mix infested with *P. ultimum* at a volume of 6.25 mL/row-ft. Fungicides were applied using a CO_2-powered backpack sprayer, equipped with TJ4002E nozzles (10.5 gal/A; 40 psi). Stand establishment was monitored early season and disease data were collected after harvest. Both rows of plots were harvested 28 Sep. While grading tubers, external leak incidence was visually estimated for the entire plot and internal leak incidence was calculated from ten arbitrarily selected tubers cut longitudinally in half. Stem counts from 6 Jul, external and internal leak incidence (DI), and estimated marketable yield (cwt/A) were compared among treatments. A generalized linear mixed model procedure was used to conduct the ANOVA and mean separations at the α=0.05 significance level (SAS version 9.4).

Significant differences were observed among stem counts ($P < 0.0001$). Stem counts in the trial ranged from 60.8 to 112.5 stems per plot, with the highest stem counts observed in programs 4, 6, and 8. No differences were observed in external DI ($P > 0.05$), though programs 3-8 had numerically greater incidences than the non-inoculated control (program 2) yet lower than the inoculated control (program 1). Internal DI was significantly different among treatments ($P < 0.05$). Programs 5 and 6 both had a DI of 1.3% and were significantly lower than the inoculated control (5.0%) but not different from the non-inoculated control (0.0%). Marketable yield was significantly different among treatments ($P < 0.05$). Program marketable yields ranged from 258 to 324 cwt/A; programs 4, 6, and 8 had the greatest yield in the trial.

No.	Treatment (Rate[z])	Stem Counts (6 Jul)[y]		External Leak Incidence (%)[x]	Internal Leak Incidence (%)[w]		Marketable Yield (cwt/A)	
1	Inoculated Control	60.8	c	13.9	5.0	ab	258	c
2	Non-Inoculated Control	64.8	c	0.4	0.0	c	263	c
3	Revus 2.09 SC (8 fl oz)	70.5	c	9.4	6.3	a	262	c
4	Orondis Gold (28 fl oz)	96.0	ab	3.5	3.8	a-c	307	ab
5	Orondis Gold DC (28 fl oz)	78.8	bc	4.0	1.3	bc	269	bc
6	Orondis Gold DC (48 fl oz)	112.5	a	3.6	1.3	bc	300	a-c
7	Elumin (8 fl oz)	67.5	c	6.0	7.5	a	280	bc
8	Ridomil Gold 465 SL (6.1 fl oz)	110.8	a	9.4	3.8	a-c	324	a

[z] All rates are listed as a measure of product per acre applied in-furrow at planting.
[y] Column values followed by the same letter were not significantly different based on Fisher's Protected LSD (α=0.05).
[x] During grading, external leak incidence was visually estimated from all harvested tubers per plot.
[w] Internal leak incidence was calculated from 10 arbitrarily selected tubers cut in half.

POTATO (*Solanum tuberosum* 'Lamoka')
Early Blight; *Alternaria solani*
Brown Spot; *Alternaria alternata*

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Evaluation of in-furrow and foliar fungicides to manage foliar diseases of potato in Michigan, 2022.

Experimental and commercially available fungicides were tested to determine their efficacy in managing potato early blight and brown spot. A field trial was established at the Montcalm Research Center in Stanton, MI. A randomized complete block design was used, and treatments were replicated four times. Soil type is a loamy sand. US#1 'Lamoka' potatoes were cut into 2-oz seed pieces and left to suberize. The trial was hand planted 1 Jun, and in-furrow treatments were applied before closing rows. A CO_2-powered backpack sprayer, equipped with TJ4002E nozzles, was used to apply fungicides in-furrow at 10.5 gal/A (40 psi). Plots were two rows wide (34-in row spacing) by 20 ft long and seeded at 1.2 seed/row-ft. Due to the trial's proximity to commercial potato fields, a blanket application of Manzate Max (1.6 qt/A) was applied weekly after row-closure to the entire trial to reduce the risk of late blight developing near commercially grown potatoes. Beginning at 50% row closure, seven foliar applications (B, C, D, E, F, G, and H) were made across programs on 14 Jul, 21 Jul, 26 Jul, 4 Aug, 10 Aug, 18 Aug, and 24 Aug. Foliar fungicides were applied at a rate of 20 gal/A (38 psi) via CO_2-powered backpack sprayer (TJ8004XR nozzles). Plots were inoculated on 28 Jul with an *A. solani* solution ($9x10^3$ conidia/mL) at 20 gal/A using the previously mentioned equipment. Stand establishment was monitored and foliar disease data (combined early blight and brown spot observations) were collected regularly throughout the growing season. The trial was harvested 29 Sep, and both rows were dug and later graded. The final disease incidence (DI), disease severity (DS), estimated yield, and estimated marketable yield (cwt/A) were compared among treatments. A generalized linear mixed model procedure was used to conduct the ANOVA and mean separations at the $\alpha=0.05$ significance level (SAS version 9.4).

Differences were observed among the foliar DI ($P < 0.0001$) and foliar DS ($P < 0.0001$) values of programs. All treated programs had significantly lower DI (38.8-66.3%) and DS (4.0-12.5%) values than the control (DI=80.0%, DS=21.3%). The lowest DI was observed in program 2, but it was not significantly different from several other programs. No significant differences were observed in yield or marketable yield. It is likely that the short infection duration due to late disease onset was not adequate time to observe differences among program yields.

No.	Treatment, Rate[z], and Timing[y]	Disease Incidence (%)[x,w]		Disease Severity (%)[w]		Total Yield (cwt/A)	Marketable Yield (cwt/A)
1	Treated Control	80.0	a	21.3	a	382	327
2	Excalia (2 fl oz) A; Elumin (8 fl oz) B; Quash WG (2.5 oz) CF; Luna Tranquility (11.2 fl oz) DG; Bravo Weatherstik (24 fl oz) EH	38.8	e	4.5	c	372	322
3	Excalia (2 fl oz) A; Elumin (8 fl oz) B; Quash SC (2.5 fl oz) CF; Luna Tranquility (11.2 fl oz) DG; Bravo Weatherstik (24 fl oz) EH	46.3	c-e	4.0	c	424	376
4	Luna Tranquility (11.2 fl oz) CE	55.0	bc	8.5	bc	369	323
5	Propulse (10 fl oz) CE	53.8	c	5.8	c	386	342
6	Miravis Prime (10 fl oz) CE	41.3	de	4.0	c	403	351
7	Endura (5.5 oz) CE	66.3	b	12.5	b	367	318
8	Exp[v] (13 fl oz) A; Delaro (6 fl oz) B; Luna Tranquility (11.2 fl oz) E	47.5	c-e	6.3	c	391	343
9	Exp (13 fl oz) A; Delaro (6 fl oz) B; Propulse (10 fl oz) E	55.0	bc	8.3	bc	383	333
10	Elatus (6.4 oz) A; Miravis Prime (10 fl oz) E	53.8	c	5.8	c	356	309
11	Velum Prime (6.5 fl oz) A; Endura (5.5 oz) BE	52.5	cd	5.3	c	365	313
12	Elatus (6.4 oz) A; Miravis Duo (13.7 fl oz) CE	46.3	c-e	5.8	c	409	359

[z] All rates are listed as a measure of product per acre. MasterLock was added to all tank mixes at a rate of 0.25 % v/v.
[y] Application letters code for the following dates: A (in-furrow)=1 Jun, B=14 Jul (50% row closure), C=21 Jul, D=26 Jul, E=4 Aug, F=10 Aug, G=18 Aug, and H=24 Aug.
[x] Column values followed by the same letter were not significantly different based on Fisher's Protected LSD (α=0.05).
[w] Final foliar disease incidence and severity ratings (combined early blight and brown spot) collected 7 Sep.
[v] Exp=Experimental compound.

2022 MSU POTATO BREEDING AND GENETICS RESEARCH REPORT
January 2023

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INTRODUCTION

At Michigan State University, we have been dedicated to developing improved potato varieties for the chip-processing and tablestock markets since 1988. The program is one of four integrated breeding programs in the North Central region supported through the USDA/NIFA Potato Special Grant. At MSU, we conduct a comprehensive multi-disciplinary program for potato breeding and variety development that incorporates plant pathology, entomology, biotechnology and genomics to meet the Michigan industry 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 and applying more efficient methods to breed improved potato varieties at the tetraploid and diploid level.

In Michigan, the primary market requires that we focus on developing high yielding round white potatoes with excellent chip-processing from the field and/or storage. In addition, there is also 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 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. The broad 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 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). We continue 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. We are benefiting from the SolCAP SNP array DNA marker technology as we can now query 35,000 SNPs (compared to 8,303 SNPs in initial array). This SolCAP translational genomics project has finally giving us the opportunity to link genetic markers to important traits (reducing sugars, starch, scab resistance, etc.) in the cultivated potato lines and then breed them into elite germplasm. The SNPs also allow us to accurately fingerprint the varieties (DNA fingerprinting database with 4,000 entries). 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, higher specific gravity and drought. In 2023, we will continue to test our engineered potatoes for late blight resistance, drought tolerance, invertase silencing and gene editing for PPO and self-compatibility. Furthermore, PotatoesUSA is supporting national early generation trials through the National Chip Processing Trial (NCPT) which will feed lines into the SNAC trials and also Fast Track lines into commercial testing (NexGen testing). This national cooperative testing is the key to determining the commercial potential of our advanced lines. This has led to the release of Saginaw Chipper (MSR061-1), Manistee (MSL292-A), Huron Chipper (MSW485-2), Mackinaw (MSX540-4), and Petoskey (MSV030-4). The next chip-processing clone for commercialization is MSZ242-13. In the table markets, Blackberry and MSV093-1Y (Bonafide) were released. We also have funding to develop genome editing technologies that may not be classified as regulated through a USDA/BRAG grant. This technology can be used to introduce lower sugars, bruising and asparagine as well several other traits in the future. We also have a USDA/AFRI diploid breeding grant to develop some foundational diploid breeding germplasm (Potato 2.0). We are also screening for new sources of late blight resistance through a USDA grant. In 2015, we were awarded the USAID grant to generate late blight resistance potatoes for Bangladesh and Indonesia and now includes Nigeria and Kenya. This Feed the Future project brings us into cutting edge GM work with Simplot and the International Potato Center (CIP). This project has been extended another 5 years beginning in 2021. 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 on current and future needs of the Michigan potato industry. Traits of importance include yield potential, size profile, 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 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. This greenhouse is located at the MSU Agronomy Farm facility on south campus. Also in 2016, we began to upgrade the potato washing and grading line. which was completed with funding from MPIC and AgBioResearch. Variable speed control drives, a new lift; custom built barrel washer; grading table; and Kerian speed sizer are all part of the set up as of 2019. Incorporation of bar-coding 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.

Varietal Development

Breeding

The MSU potato breeding and genetics program is actively producing new germplasm and advanced seedlings that are improved for long-term storage chipping, and resistance to scab, late blight, and Colorado potato beetle. For the 2022 field season, progeny from about 300 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, red skin, and specialty market classes. During the 2022 harvest, about 1,000 selections were made from the 40,000 seedlings produced. Most of these first-year selections are segregating for PVY resistance. All second, third or fourth- year potential chip-processing selections will be tested in January and April 2023 directly out of 45°F (7.2°C) storage. Atlantic, Lamoka, Manistee and Snowden 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 on chip quality, specific gravity, scab resistance, late blight resistance and DNA markers for PVY and Golden nematode resistance. Most of our selections now have PVY resistance. Selection in the early generation stages has been enhanced by the incorporation of the scab and late blight (US-23) evaluations of the early generation material. We are pushing our early generation selections from the 30-hill stage into tissue culture to minimize PVY issues in our breeding and seed stock. We are now using a cryotherapy method as well as the traditional methods that was developed in our lab to remove viruses. This technique predictably and quickly removes virus from tissue culture stocks. Our results show that we can remove both PVY and PVS from lines, but PVS can still be difficult to remove in certain lines if the titer is high. We tested the removal of PLRV and succeeded. Over 1500 different varieties and breeding 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. We prioritize scab resistance and PVY resistance in our chip-processing selections. Our most promising advanced chip-processing lines are MSZ242-13 (scab resistant, high solids), MSAA217-3, MSBB058-1 (scab resistant), while MSBB630-2, MSBB636-11 and MSZ614-15 all combine scab, late blight and PVY resistance). We have some newer lines to consider such as. With a successful late blight trial in 2022, we were able to confirm resistance in some of our advanced selections. We are using the NCPT trials to identify promising new selections more effectively. Manistee and Mackinaw were licensed to Canada. Saginaw Chipper and Mackinaw are in Australia and South Korea.

Tablestock

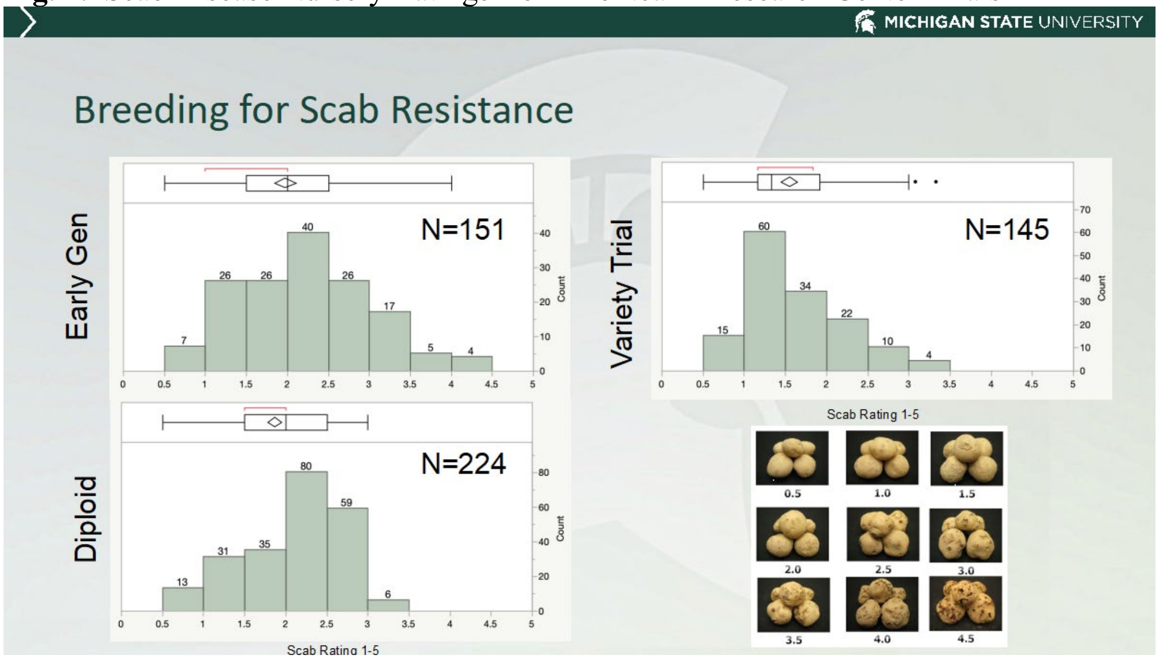
Efforts have been made to identify lines with good appearance with an attractive skin finish, low internal defects, good cooking quality, high marketable yield and resistance to scab, late blight and PVY. Our current tablestock development goals now are to continue to improve the frequency of scab and PVY resistant lines, incorporate resistance to late blight along with marketable maturity and excellent tuber quality, and select more red-skinned and yellow-fleshed lines. We have also been selecting some pigmented skin and tuber flesh lines that fit some specialty markets. There is also interest in some additional specialty mini-potatoes for the "Tasteful Selections" market. We have interest from some western specialty potato growers to test and commercial these lines. From our breeding efforts we have identified mostly round white lines, but we also have several yellow-fleshed and red-skinned lines, as well as some purple skin selections that carry many of the characteristics mentioned above. PVY resistance is incorporated into these different table market classes. Some of the tablestock lines were tested in on-farm trials in 2022, while others were tested under replicated conditions at the Montcalm Research Center. Promising tablestock lines include MSCC553-1R which is scab and PVY resistant. MSZ416-8RY (scab resistant) is being licensed by Pro-Health. MSZ109-8PP, a sib of Blackberry is a purple-fleshed chipper with deep purple flesh, round shape and attractive skin as well as scab resistance. We are working with Chris Long to select a new cohort of red-skinned and yellow-fleshed potato lines. Jacqueline Lee (late blight resistant) was licensed to Australia and is being grown in Central America for its late blight resistance. Raspberry, Blackberry, MSQ558-2RR (Ruby Rose) and our PVY resistant Red Marker #2 (Spartan Red) potato are being marketed in the specialty markets. Blackberry is also being chip-processed by the Great Lakes Chip Co. in Traverse City, MI. We are currently collecting nutritional data on the antioxidants in Blackberry tubers and chips that may enhance the marketing of this variety.

Disease and Insect Resistance Breeding

Scab: In 2022, we had evaluated scab resistance at a highly infected site at the Montcalm Research Center. The Montcalm Research Center site gave us very good scab infection levels. The susceptible checks of Snowden and Atlantic were highly infected with pitted scab. Promising resistant selections will be summarized in the variety report. If you examine the variety trials at Montcalm Research Center in the variety report, you will notice that many of 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 as well as table yellow and red. 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 this data, scab resistance is strong in the breeding program. We lead the nation in scab resistant lines. This is evident in the NCPT. 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. Also, the ability to select under commercial settings at Sackett Potatoes is accelerating our ability to select for highly scab resistant varieties. Many highly scab resistant lines (score < 1.0) coming from this effort are MSBB614-15, MSCC282-3RR, MSDD085-13, MSDD247-11, MSEE101-2, MSEE207-2, MSW474-1, MSEE048-2Y, MSFF334-1Pinto, MSAA076-04, MSAA076-6, MSAA498-18, MSBB012-1Y, MSCC376-1, MSDD244-15, MSFF073-3 and MSFF178-1.

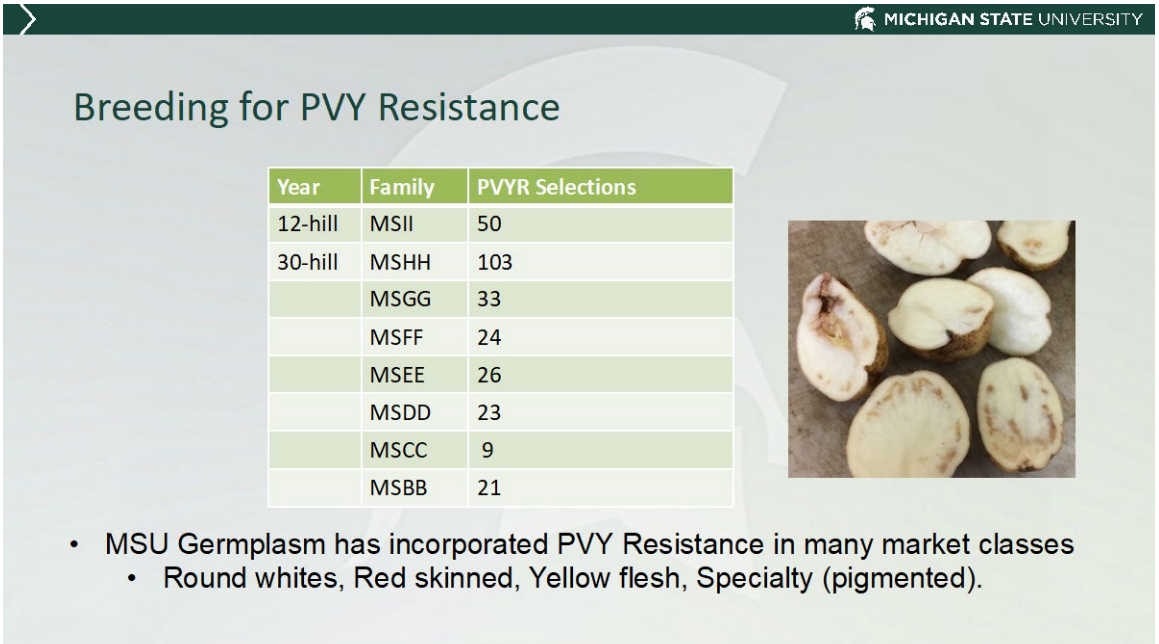
Fig. 1. Scab Disease Nursery Ratings from Montcalm Research Center Trials



Late Blight: Our specific objective is to breed improved cultivars for the industry that have foliar and tuber resistance to late blight using a combination of conventional breeding, marker-assisted strategies, and transgenic approaches. Through conventional breeding approaches, the MSU potato breeding and genetics program has developed a series of late blight resistant advanced breeding lines and cultivars that have diverse sources of resistance to late blight. In 2022 we conducted late blight trials at the MSU campus. We inoculated with the US23 genotype and obtained infection. The infection progressed and we were able to confirm late blight resistance for Mackinaw, Huron Chipper and numerous breeding lines such as MSBB058-4. The late blight trial results are summarized in the variety report. We will continue with late blight trials in 2023 on the MSU campus.

PVY: We are using PCR-based DNA markers to select potatoes resistant to PVY. The gene is located on Chromosome 11. Each year since 2013 we are making new crosses, making selections, and expanding the germplasm base that has PVY resistance (Fig. 2). In the past year we tested over 1,000 progeny for the PVY resistance marker. The 400 that were marker positive were evaluated at Lake City. With the development of molecular markers for potato breeding, marker-assisted selection has been incorporated into our routine breeding practice and greatly facilitate the selection process. At times we are using DNA markers to also screen for PVX resistance, PLRV resistance, late blight resistance and Golden nematode resistance. DNA markers allow for a prioritization of the space in the field, and for earlier, more informed decisions in variety selection.

Fig. 2 PVY resistant selections in the breeding program



MSU Lines with Commercial Tracking

MSV093-1Y (Bonafide)

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*).

Petoskey (MSV030-4)

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

Strengths: Petoskey is a chip-processing potato with resistance to common scab (*Streptomyces scabies*). This variety has high specific gravity and yield potential, with attractive, uniformly round tubers. Petoskey has a medium vine and a mid-season maturity and has demonstrated excellent long-term storage chip-processing quality. MSV030-4 has performed well in Michigan and 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 high specific gravity and resistance to common scab, and a good size profile of uniform, round tubers.

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-full season maturity.
Tubers: Smooth, round tubers with lightly netted, tan colored skin and white flesh.
Yield: Above average yield under irrigated conditions, with uniform tubers.
Specific Gravity: Averages higher than Atlantic and Snowden.
Culinary Quality: Chip-processes from short and long-term storage.
Diseases: Resistant 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: MSW485-2 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*).

Blackberry (MSZ109-10PP)

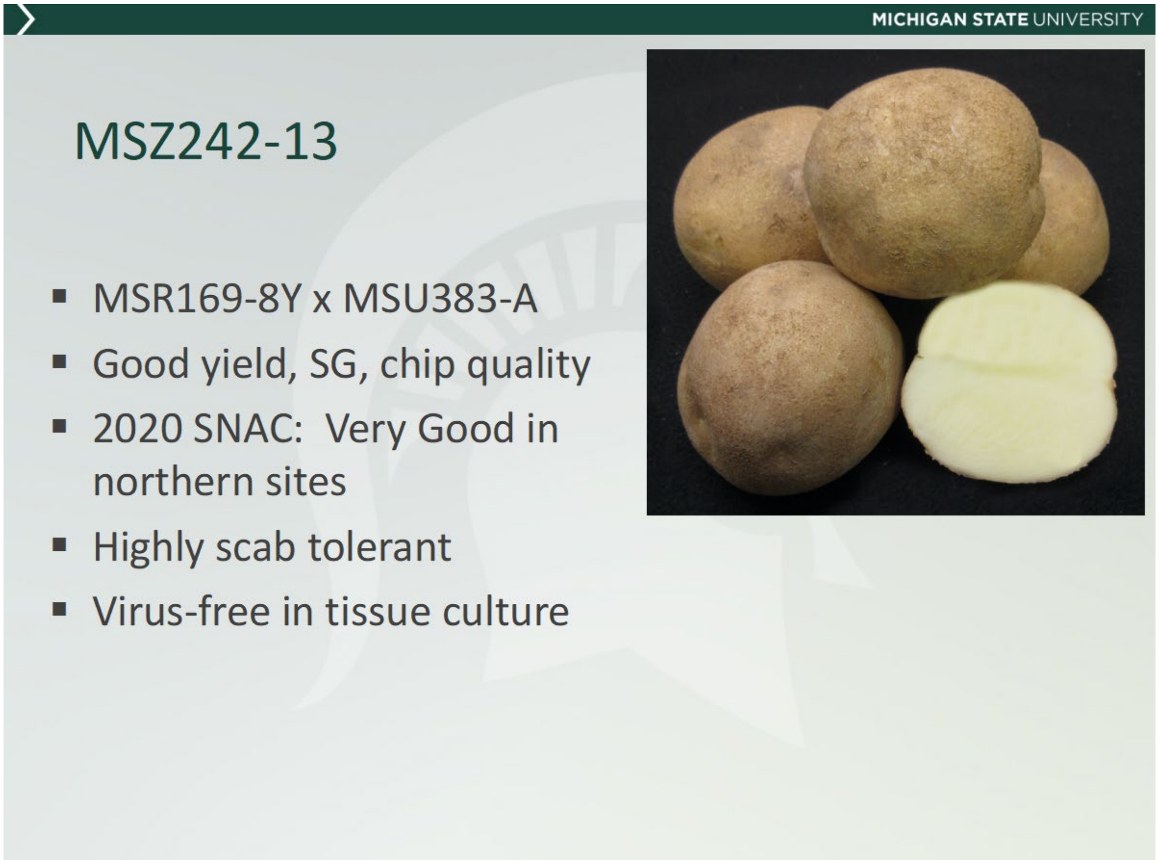
Parentage: COMN07-W112BG1 x MSU200-5PP
Developers: Michigan State University and the MSU AgBioResearch
Plant Variety Protection: To Be Applied For.

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: Above average yield.
Specific Gravity: Averages 1.065 in Michigan.
Culinary Quality: Gourmet specialty with deep purple flesh and also chip-processes.
Diseases: Good common scab resistance.



Decoding *S. chacoense*-derived and other new sources for Colorado Potato Beetle Resistance

Our goal is to provide durable Colorado potato beetle management in an integrated,sustainable manner. With this research we should be able to move towards developingresistant diploid parental lines for commercial breeding purposes. Our current objectiveis to evaluate the transmission of *S. chacoense* host plant resistance in a set of diverse cultivated diploid clones.

We made crosses with the best CPB resistant inbred line ‘431”. Using inbred 431 will more likely transmit resistance to a greater percentage of the progeny because the genes related to insect resistance are more likely fixed. Selfing will then recover the homozygous condition of recessive loci contributing to beetle resistance. In 2022 the beetle pressure was weak after the first emergence, so we made selections in the families for tuber appearance. We will run detached leaf bioassays in the winter to screen the progeny for resistance.

We also have four hybrids between our diploid germplasm and other wild potato species with non-leptine-based resistance were identified to have an extremely high level of resistance to Colorado potato beetle. Two of the lines were hybrids that are 50% cultivated diploid germplasm. These lines we tested attracted the beetles (both large larvae and adults) but after a small amount of feeding, the beetles dropped from the plant and died. These lines offer opportunities to pyramid the resistance mechanisms as we move forward with our breeding for Colorado potato beetle resistance.

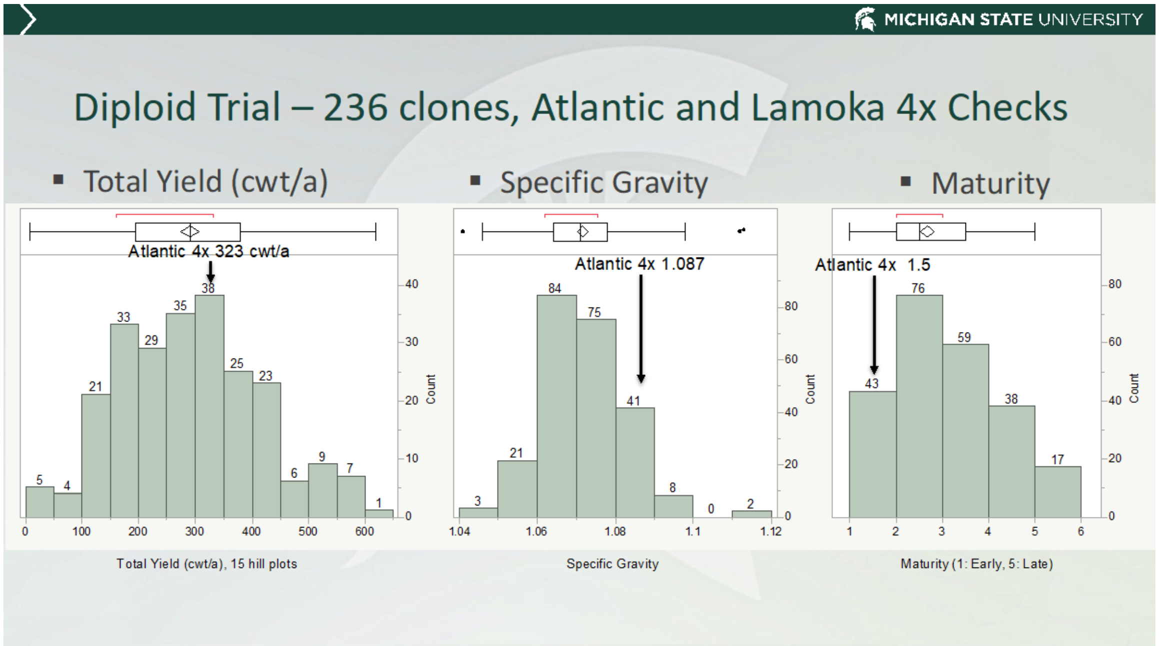
Dihaploid Potato Production at Michigan State University

The benefits of developing a richer germplasm of dihaploid potatoes brings the industry ever closer to the expansive changes that would come with diploid potatoes. Our goal is to develop a broad-based dihaploid germplasm that can be used in diploid potato breeding. We started by crossing currently established MSU tetraploid germplasm with a known haploid inducer, *S. phureja* IVP 101. Parent lines were selected based on traits such as high yield, disease resistance, and good chip quality, among others. Confirmed dihaploids are crossed with a diploid self-compatible lines to introgress self-compatibility. From the crosses produced in the past 8 years from these dihaploid crosses with over 60 breeding lines or varieties, about 900 progeny have been confirmed as diploid. These dihaploids (diploids derived from tetraploid varieties) are the foundation of our diploid breeding program for round white potatoes for the chip and table markets. We have also now selected some russet dihaploids and red dihaploids and well as more chippers, table and russets in 2022. Right now we have about 100 good female fertile dihaploids that are forming the core of our varietal diploid breeding program.

Diploid Breeding

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 have cycled 5 generations to improve for self-compatibility and tuber traits. We have also been crossing self-compatible donors to the dihaploids of Atlantic, Superior, Manistee, MSZ219-14, Kalkaska, MSR127-2, MSS576-5SPL and others 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.

In 2022, we yield tested about over 200 lines. In 2021 over 30 lines were equal or better than Lamoka and Atlantic in yield. In 2022 we saw similar results with over 100 lines equal or better than the Atlantic check.



Certified NFT Minituber Production at Michigan State University

Since 2016, the MSU Potato Breeding program has operated its own certified NFT minituber production greenhouse. The ability to produce certified seed allows faster introduction of early generation material to the potato industry. It also helps position the program for participation in international trials.

MICHIGAN STATE UNIVERSITY

2022 Certified Seed Production at MSU

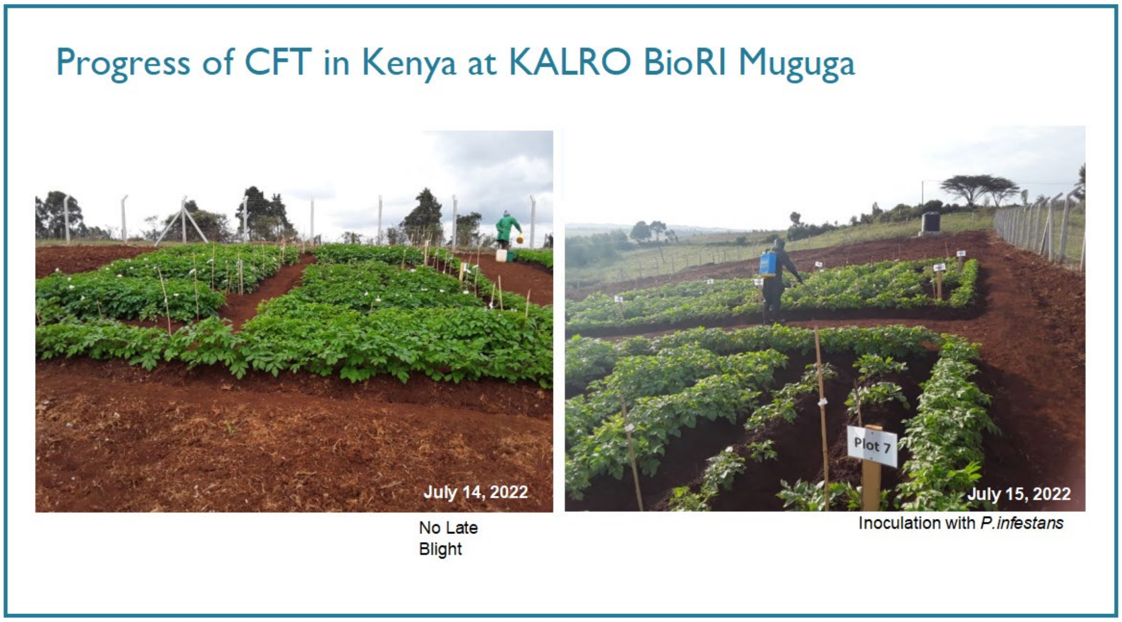
- 29 Clones, 35,000 Minitubers

Line	Tubers	Remarks
Blackberry (MSZ109-10PP)	2000	
Bonafide (MSV093-1Y)	1000	
Raspberry	1300	
Spartan Red #2 (Red Marker #2)	3000	PVYR
NDAF113484B-1	5300	
MSBB630-2	1300	PVYR
MSCC553-1R	150	PVYR
MSDD376-4	1200	PVYR
MSFF182-1R	500	PVYR
MSW474-1	800	
MSZ109-05RR	1900	
MSZ109-07PP	600	
MSZ242-13	600	

Line	Tubers	Remarks
DIA-MSU-UB015	2300	USAID-LB
DIA-MSU-UB255	2000	USAID-LB
Diamant	2500	USAID-Check
GRA-MSU-UG234	2000	USAID-LB
GRA-MSU-UG265	1700	USAID-LB
GRA-MSU-UG269	500	USAID-LB
Granola	2000	USAID-Check

Integration of Genetic Engineering with Potato Breeding

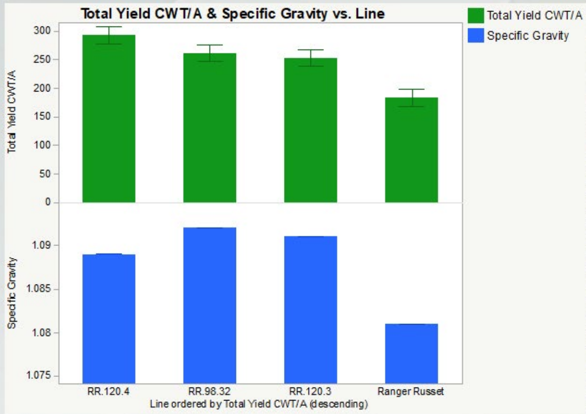
MSU conducts genetic engineering research to introgress and test economically important traits into potato. We have a USAID-funded project to create and commercialize 3-R-gene potato varieties in Bangladesh, Indonesia, and Africa. This a partnership with Simplot Plant Sciences. Simplot has been creating the plants for the target countries. Agronomic and late blight trials in Indonesia demonstrate their resistance to late blight and yield well under late blight pressure.



We have also generated lines with the genes for water use efficiency. The XERICO gene is showing the most promise. From 2018 to 2022, we conducted trials at MRC with Ranger Russet events. These results are indicating that we are not seeing a yield reduction from the XERICO gene and the XERICO events also had a higher specific gravity than Ranger Russet. Field trials at MRC in 2022 confirm this observation. Lastly, we have generated and selected a Kalkaska invertase silencing line (Kal91.03) that has resistance to accumulating reducing sugars in cold (40°F) storage. We tested the agronomic characteristics of Kal91.03 from 2016-2022. 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. Our plan is to petition the USDA for exemption from regulation.

2022 XERICO Field Trials at MSU

- Test trait in potato *in situ*
- No yield penalty
- Increase in starch content



Objective 1. Develop a Colorado potato beetle (CPB) degree day model on the MSU Enviroweather website.

Enviroweather programmers used the weekly sampling of CPB conducted in 2022 by the MSU Vegetable Entomology lab to track the development of Colorado potato beetle (CPB) at 20 commercial potato fields in Michigan. Temperature data from the nearest Enviroweather station to each field were used to calculate GDD_{base52} for each sample date to determine and compare when the first, peak and end of emergence occurred for CPB adults, eggs, and larvae (Fig. 1). There was not clear agreement between previous research and the current observations. Among sites in Michigan observations and GDD_{base52} were also inconsistent due to different planting dates, amount of pest pressure, timing of control measures, etc. Due to this variability we used the data from seven fields near Entrican, MI with heavy CPB pressure to construct smoothed lines depicting the phenologies of CPB life stages (Fig. 1). This figure shows how the model will function, and is a prototype for the model display that will appear on Enviroweather. The graphs represent the typical progression of different life stages of CPB based on degree days. The current relative abundance of a given stage is shown by solid red circles, and expected abundance based on the forecasted degree days totals are shown by green circles. Because this model predicts conditions using seven days of forecasted temperatures, growers can use this model to decide if management will be needed in the near future. The model will also be paired with a description page that will provide additional information on pest biology and management. Links in the model will take the user to recommendations for control of key developmental stages. In addition the model will show whether the first or second generation is occurring so growers will know when to switch insecticide classes for resistance management.

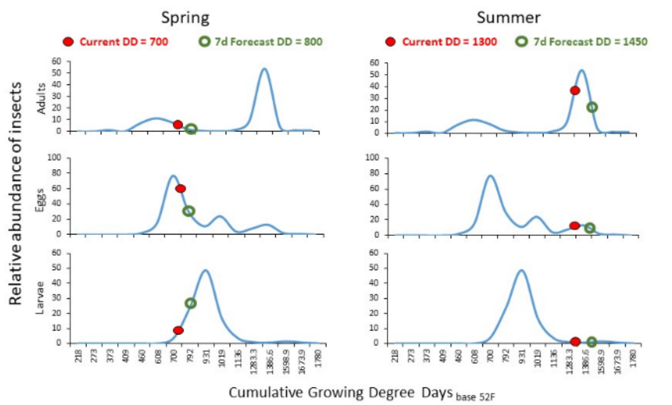


Figure 1.Relationship between GDD and abundance of CPB Adults (top row) Eggs (middle row) and Larvae (bottom row). Each graph shows a typical emergence pattern for each life stage through the growing season. These graphs demonstrate how the model will function during the season. The model will display the current level of abundance based on current GDD (red circles), while green circles show the estimated abundance based on 7 days of temperature forecasts. Example graphs of model displays during a typical Spring are shown in the left hand column and a Summer scenario is shown in the right hand column.

The CPB model will be similar to Enviroweather's Asparagus Miner model in its form and function. As it is being developed and revised, the model will be a part of Enviroweather's development website and will be made available to project collaborators through MSU's firewall, but will not be available to the general public. We expect to release the model to the public for the 2023 growing season.

Objective 2. Validate the Colorado potato beetle model in Michigan potato fields.

We collaborated with commercial growers, extension staff, pest scouts and pest managers to locate fields with known CPB pressure. Twenty commercial fields in the main potato growing areas of Michigan (Montcalm, Saginaw, Kalkaska counties) were used for scouting for CPB life stages. We visited weekly these commercial potato fields from the time that plants started emerging from the ground to senescence at the end of the growing season. In each field, we randomly picked 50 plants and counted the number of CPB life stages on the whole plant.

Objective 3. Extend findings to growers and help model adoption on a wide scale.

In 2023, once we are confident that the degree day model can accurately predict CPB life stages across MI potato growing areas, we will help growers and pest managers to familiarize themselves with the new CPB degree day model. We will publish news articles on the MSUE News website and in Potato Country magazine; we will talk to growers about the model at various extension meetings such as the potato field day at the Montcalm Research Center and at the Great Lakes Expo in the potato session. We will also present a talk at the Winter Potato Conference, which is the major extension meeting for commercial potato growers in MI. We will also work with the Michigan Potato Commission to release an educational article in their weekly newsletter and post it on their website. The article will also be linked on the MSU Vegetable Entomology website under the Potato subpage.

2021-2022 MICHIGAN POTATO DEMONSTRATION STORAGE ANNUAL REPORT MICHIGAN POTATO INDUSTRY COMMISSION

Chris Long, Coordinator, Trina VanAtta, and Damen Kurzer

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 evaluate 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 highly important 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 allows 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 variety's 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 monthly or 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 2021-2022 storage season. Section I, "2021-2022 New Chip Processing Variety Box Bin Report", contains the results and highlights from our 10-cwt. box bin study. Section II, "2021-2022 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. Brian Sackett, Sackett Potatoes; Todd Young, and Chase Young, Sandyland Farms; Jeff Thorlund, Thorlund Brothers Farm; and Karl Ritchie and Brice Stine of Walther Farms for provided the material to fill the bulk bins this year; without their willingness to be involved, we could not have accomplished our objectives. Equal in importance are the processors who invested in this research. They are Gene Herr and Ellis Cole of Herr Foods, Ira and Dave Middleswarth of

Middleswarth Potato Chips, James Lowell of Campbells Soup Company, and Jim Allan of Shearer's Foods. 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 and Abe Bakir (Techmark, Inc), 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 2021 Production Season

The overall 6-month average maximum and minimum temperatures during the 2021 growing season in central Michigan was consistent with the 15-year average temperatures. May had cooler minimum temperatures than average while June and August had warmer minimum temperatures than average. Maximum temperatures were higher than average in April, June, and August (Table 1). There were no daytime heat stress events in 2021 when the temperature was over 90^{o}F. Nighttime heat stress hours and days over 70^{o}F were both above average. In 2021 there were 168 hours over 35 days with elevated nighttime temperatures (Table 2).

Rainfall for April through September was 21.49 inches, 3.55 inches above the 15-year average. June and July both had over two inches more rainfall than average. This was the highest rainfall recorded in July, and second highest in June over the past 15 years. April and May were both dryer than average, with each month's rainfall over an inch less than the 15 year average (Table 3).

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.
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	73	49
2015	58	33	71	48	76	54	80	56	77	57	77	54	72	49
2016	53	32	70	45	78	53	82	60	85	60	78	54	73	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
2019	55	35	65	45	75	54	84	69	80	55	73	54	72	52
2020	56	29	76	35	77	54	81	68	78	60	70	48	73	49
2021	**58**	**35**	**69**	**41**	**80**	**58**	**81**	**58**	**85**	**59**	**76**	**50**	**75**	**50**
15-Year Average	56	33	71	45	78	55	82	60	80	57	74	50	73	50

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

Year	Temperatures > 90°F		Night (10pm-8am) Temperatures > 70°F	
	Hours	Days	Hours	Days
2016	10	3	147	31
2017	14	3	80	18
2018	12	4	123	31
2019	0	0	104	20
2020	12	3	123	30
2021	**0**	**0**	**168**	**35**
Average	8	2	124	28

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
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
2019	2.64	5.46	2.90	2.04	3.31	5.72	22.07
2020	3.49	4.75	1.40	4.07	2.21	3.12	19.04
2021	**1.71**	**2.18**	**5.58**	**4.79**	**3.52**	**3.71**	**21.49**
15-Year Average	3.20	3.25	3.00	2.55	3.36	2.58	17.94

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

I. 2021-2022 New Chip Processing Variety Box Bin Report

(Chris Long, Trina VanAtta, Damen Kurzer, 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 contains 36 10 cwt. boxes. We organized the 36 boxes into 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 or monthly quality evaluations.

Procedure

In 2021, we evaluated and compared 34 new varieties to the check variety Snowden. Once the varieties were chosen, 1 cwt. of most varieties were planted in a single 34-inch wide row. Some varieties were planted in one half of a row for monthly sampling. Planting occurred on May14th at the MSU Montcalm Research Center, Entrican, MI. We planted the varieties at a 10" in-row seed spacing. All varieties received the following fertilizer: 273 lb. N/A, 98 lb. P_2O_5/A and 261 lb. K_2O/A. The varieties were vine killed after 117 days and allowed to set skins for 40 days before harvest on October 18th and 19th, which was 157 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. For varieties sampled monthly, approximately eight trays of tubers were stacked on top of the box bins. The average storage temperature for all the box bins was 54.0ºF for the 2021-2022 season. At harvest, we collected nine, 20 lb. samples from each full row 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 in Table 5. We graded the varieties to remove all "B" size tubers and pickouts, ensuring the tubers began storage in good physical condition.

The storage season began September 18th, 2021, and ended June 6th, 2022. Bin 7 was gassed with DMN and CIPC on November 16th and February 16th. We began variety evaluations on November 1st, followed by a bi-weekly or monthly sampling schedule until early June. We randomly selected forty tubers from each box every two weeks or one month 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, canr.msu.edu/potatooutreach.

Table 4. 2021-2022 MPIC Demonstration Chip Box Bin Variety Descriptions

Entry	Pedigree	2021 Scab Rating*	Characteristics
Blackberry	COMN07-W11BG1 x MSU200-5PP	2.0	Above average yield, low specific gravity, good internal quality
CO11037-5W	BC0894-2W x Nicolet	1.0	Average yield and specific gravity, larger vine type, medium netted skin
CO12293-1W	CO02024-9W x ND7519-1	2.5	Very high yield, uniform tubers with light skin, common scab susceptible
COOR13270-2	Winterset x CO02024-9W	1.5	Very low yield, small tuber size profile, inconsistent skin, smaller vine type
Lady Liberty	B38-14 x Marcy	0.0	Above average yield, light netted skin, good chip and internal quality
Mackinaw	Saginaw Chipper x Lamoka	1.0	Average yield, flattened tubers with netted skin, good internal quality
MSAA076-04	MSR127-2 x MSS297-3	1.0	Uniform heavy netted skin, nice appearance, good chip quality
MSAA076-6	MSR127-2 x MSS297-3	1.5	Deep apical eyes, light netted skin, above average yield
MSAA217-3	Beacon Chipper x Atlantic	1.5	Very high yield and specific gravity, moderate hollow heart, high proportion A-sized tubers
MSAA252-7	NY148 x MSQ089-1	1.5	Large blocky round type, very high yield, high proportion A-sized tubers
MSAA260-3	MSQ086-3 x Atlantic	1.5	Round blocky uniform type, high yield, good internal quality
MSAA328-4	Boulder x MSR169-8Y	0.5	Less uniform blocky oval type, very low yield, large vine type with early vine maturity
MSAFB609-12	NY148 x MSQ086-3	3.0	Less uniform pointed tubers, below average yield and specific gravity, smaller tuber size profile

Entry	Pedigree	2021 Scab Rating*	Characteristics
MSAFB635-15	NYH15-5 x MSS297-3	1.0	Average yield, higher specific gravity, good chip quality
MSBB058-1	NY148 x MSR127-2	1.5	Very high specific gravity, average yield, small round type
MSBB079-2	MSS927-1 x MSR127-2	0.5	Uniform round type, medium netted skin, above average yield
MSBB230-1	NY148 x MSQ089-1	2.5	Below average yield, smaller round blocky type, high specific gravity
MSBB614-15	Saginaw Chipper x MSR127-2	0.5	Below average yield and specific gravity, moderate internal defects, large vine type
MSBB626-11	Saginaw Chipper x Kalkaska	1.0	Average yield and specific gravity, light netted skin, deeper eyes
MSBB634-8	Lady Liberty x MSR169-8Y	0.5	Low yield, flattened blocky type, full season vine maturity
MSBB635-14	Lady Liberty x MSS297-3	1.5	High yield, sticky stolons, compressed tuber shape, moderate vascular discoloration
MSCC058-01	MSK061-4 x Manistee	2.0	Round uniform type, medium netted skin, below average yield, high specific gravity
MSCC376-01	MSR127-2 x Manistee	0.5	Deeper apical eyes, netted skin, below average yield and specific gravity
MSDD085-13	NY148 x MSR127-2	1.5	Very low yield, smaller tuber size profile, small vine type with early vine maturity
MSW474-1	MSN190-2 x MSP516-A	0.5	Above average yield and specific gravity, uniform round type, good chip quality
MSZ242-07	MSR169-8Y x MSU383-A	1.0	Very high yield, growth crack in pickouts, average specific gravity

Entry	Pedigree	2021 Scab Rating*	Characteristics
MSZ242-13 (Monroe)	MSR169-8Y x MSU383-A	0.5	Round to oval type, highest specific gravity in the trial, high proportion A-sized tubers
NY163 (Bliss)	NYE50-8 x NYE48-2	0.5	Less uniform type, below average yield, good chip quality, moderate vascular discoloration
NY172	Lady Liberty x F31-3	2.0	Slight skinning, average yield, common scab susceptible, larger vine type
NY173	J110-12 x F31-3	1.5	High yield, light skin, some pitted scab lesions, smaller size profile
NY174	NY148 x E48-2	1.5	Above average yield, moderate skinning, variable skin finish
NYR101-2	Snowden x E48-2	1.5	Very small tubers and low US#1 yield, early vine maturity, lighter skin
Petoskey	Beacon Chipper x MSG227-2	1.5	Very high specific gravity, heavier netted skin, below average yield
Snowden	**B5141-6 x Wischip**	**2.0**	**Moderate vascular discoloration, larger vine type, common scab susceptible**
W12078-76	Hodag x Lelah	1.0	Average yield, attractive round uniform type, good chip quality

*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.

Results: 2021-2022 Chip Processing Box Bin Highlights

MSZ242-13

This variety has been evaluated by the Potato Outreach Program since 2016. At harvest, the specific gravity was 1.106, the highest in the trial and well above the average of 1.086. The US#1 yield was 345 cwt/A, slightly below average. Two pre-harvest samples were taken on August 15th and August 29th in which stable glucose and decreasing sucrose indicated potential chemical immaturity. This variety exhibited mid-season maturity, below average common scab incidence, and a higher percentage of US#1 tubers. It had good out of the field chip quality, with a 1.0 chip score and less stem end defect than the trial average (Table 5). Sucrose concentrations were initially high, remained elevated through February, and then decreased through May. They rose to the highest level at bin unloading on 6/6/22. Glucose concentrations were more stable, fluctuating between 0.001% and 0.003% during storage in all but the last two samples. There were only three samples with undesirable color, all below five percent. Internal chip color was also very good, with only the first and last sample displaying this defect. Total defects were generally low and three samples, including the final, had defects less than ten percent. Most samples had slight stem end color and bruising. This variety maintains good chip quality through early June and continues to demonstrate long term storage potential in Michigan. It has been named Dundee and is still under evaluation for commercialization.

Figure 1. MSZ242-13 chip samples at the first processing date (10/18/21) and last processing date (6/6/22).

NY163

This Cornell University variety has been evaluated for five years by the Potato Outreach Program. It had a below average yield potential of 325 cwt/A US#1 tubers, partially due to small tuber size. It also had an average specific gravity of 1.088 and good chip quality with no stem end defect observed during chipping right after harvest (Table 5). Between the two pre-harvest samples, stable glucose and decreasing sucrose indicate chemical maturity. During initial bin cooling the sucrose was stable and remained consistent until the last two samples in May. Glucose remained low and stable until late April, after which it rose in the final four samples. Chip color was excellent during storage, with only one incidence of undesirable color in November. However, internal color was initially excellent but then sharply rose in the last two samples, ending at 84.9% internal color defects. Correspondingly, total defects were low during most of storage, but rose in the final chip samples. Chip quality was good from September to early April but quickly decreased through May. This variety will be further evaluated in the 2022-2023 Box Bin trial, as it demonstrates long-term storage potential with minimal chip defects until April. NY163 has been named Bliss and is still under evaluation.

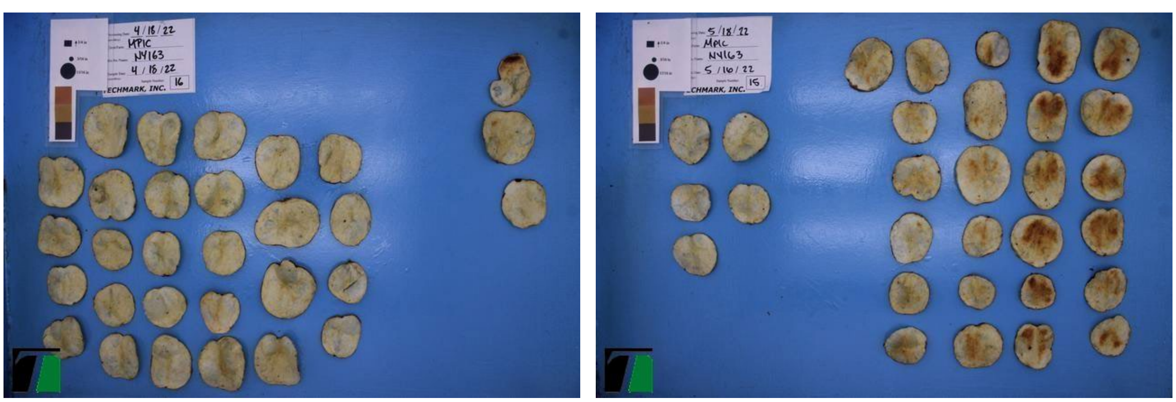


Figure 2. NY163 chip quality on last acceptable sample date, 4/18/22 (left) and last storage sample, 5/17/22 (right).

MSW474-1

This Michigan State University variety was first evaluated by the Potato Outreach Program in 2015. It had an above average US#1 yield of 446 cwt/A and higher than average total yield of 540 cwt/A in the 2021 Box Bin trial. It had 83% A-sized tubers, consistent with the trial average. The specific gravity and chip color were also consistent with the trial average, while both the common scab score and stem end defect rating were lower than average. Internal quality was excellent with no defects observed in 2021 (Table 5). Decreasing sucrose indicates chemical maturity at harvest. Sucrose concentrations were stable for much of harvest, but rose in May and June, ending at 1.150%X10 at the last sample. Glucose concentrations were more variable, reaching the highest concentration, 0.012%, in early February. There was no undesirable color observed for the duration of storage. Slight internal color was present but was below ten percent in all but one sample. Total defects were also variable, with some samples below ten percent defects and some over 45% defects. Most samples had bruising, and some had slight stem end color. MSW474-1 has long term storage potential at 54ºF through June. It will be further evaluated in the 2022-2023 Box Bin trial.

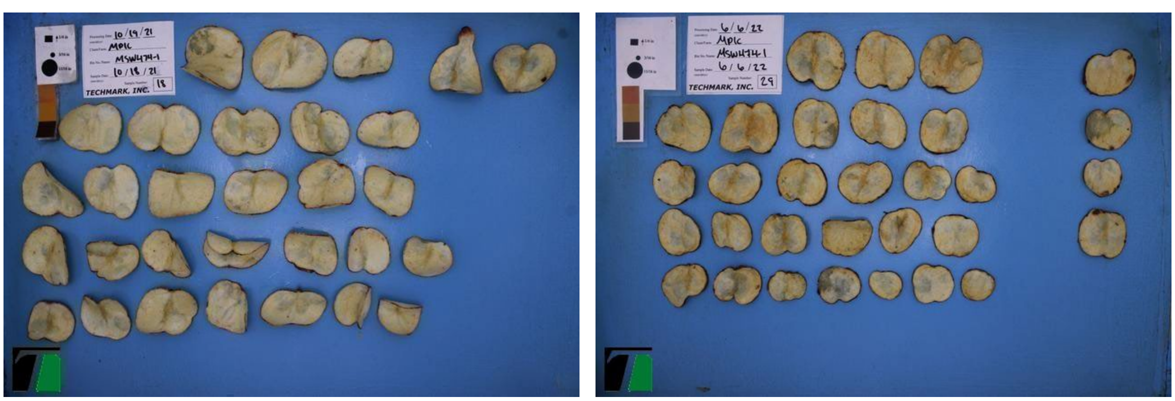


Figure 3. MSW474-1 chip quality on the first (10/18/21) and last sample dates (6/6/22).

MSBB058-1

This Michigan State University variety has been evaluated by the Potato Outreach Program since 2019. It had an average US#1 yield of 370 cwt/A and total yield of 446 cwt/A. The size profile was consistent with the trial average. The specific gravity was very high, 1.096, well above the trial average of 1.086. Chip color, common scab rating, and stem end defect were also consistent with the trial average (Table 5). Between the two harvest samples, increasing glucose and sucrose indicated potential chemical immaturity at harvest. Sucrose was initially elevated, but decreased through May, reaching the lowest value of 0.277%X10 that month. At the final sample in June the sucrose rose again. Glucose concentrations were more variable, with initially high levels that decreased and remained low from December to May. Corresponding to the rising sucrose in the final sample, the glucose concentration was also elevated in June. Only two samples displayed undesirable color, both below five percent. Three samples also had slight internal color. Total defects were variable. Three samples in December, February, and April had few defects, but the sample in March had 100% defects. The final chip sample in June had 25.2% defects. This variety will be further evaluated in the Box Bin with bi-weekly sampling instead of the monthly sampling that occurred in 2021-2022.

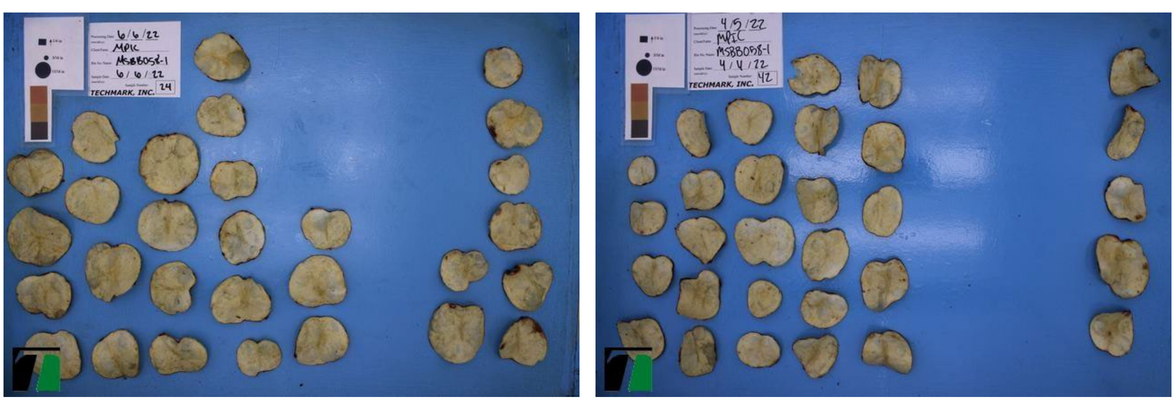


Figure 4. MSBB058-1 chip quality on last acceptable sample date, 4/4/22 (left) and last storage sample, 6/6/22 (right).

Snowden

This variety was included as a commercial standard for the 2021-2022 Box Bin trial. It had a slightly below average US#1 and total yield. The size profile and specific gravity were consistent with the trial average, but 20% vascular discoloration was observed, higher than average. Chip quality was good, with a SNAC color score of 1.0 and no stem end defect observed (Table 5). In 2021 this variety had a larger vine type and earlier vine maturity than average. Snowden was chemically mature at harvest, with an increasing glucose concentration and decreasing sucrose rating. In storage, sucrose concentrations fluctuated but decreased by early January, and remained low until May. At the end of storage the concentrations rose, ending at a high of 1.232%X10 in late May. Glucose concentrations were elevated in November but decreased and remained low through May. Concentrations rose in the last two samples, with a final value of 0.010%. Snowden had good chip quality though most of storage, with no undesirable color, and limited internal color excluding the last two samples. Total defects were also generally low but rose in May. The final sample had 60% defects, caused by bruise and sugar browning due to elevated free sugars. Snowden continues to be grown and stored in Michigan and remains the standard for the Box Bin trials.

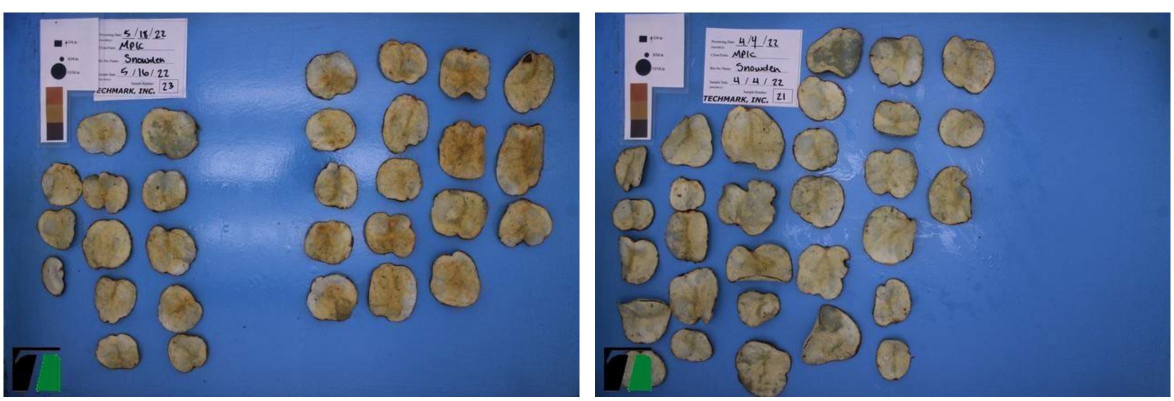


Figure 6. Snowden chip quality on last acceptable sample date, 4/4/22 (left) and last storage sample 5/16/22 (right).

II. 2021 - 2022 Bulk Bin (500 cwt. Bin) Report

(Chris Long, Trina VanAtta, Damen Kurzer, and Brian Sackett)

Overview and Objectives

The goals of the MPIC Storage and Handling Committee for the 2021-2022 bulk bin storage season were: 1. To study storage quality of MSZ242-13 and determine if storage quality merits further variety evaluation 2. To refine optimal storage profiles for NY163, specifically to determine optimal target temperature and storage duration 3. To determine a storage profile for MSW474-1 4. To evaluate the rate of bin cooling on tuber sugar conversion and chip quality in Petoskey.

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 the designated bulk bins were filled. The varieties and their storage management strategies were established by the MPIC Storage and Handling Committee. For each bulk bin filled, a corresponding box bin containing 10 cwt. was filled and placed into Bin 7. Bin 7 was held at 54ºF, which in most cases is warmer than the corresponding bulk bin of the same variety. This allowed the committee to see if the warmer storage temperature in the box bin would reduce storage life and provided information as to how the bulk bin tubers might physiologically age. All bulk bins were treated with DMN and CIPC on November 16th and February 16th.

Bulk bin assignments are below:
1: MSZ242-13 (Walther Farms)
2: NY163 (Sandyland Farms)
3 and 4: MSW474-1 (Thorlund Brothers)
5 and 6: Petoskey (Walther Farms)
7: Box Bins
8 and 9: Mackinaw Pathology Study (Sackett Potatoes)

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.

MSZ242-13 Storage Trial (Bin 1)

MSZ242-13, a promising variety from Michigan State University, has commercialization potential in Michigan due to a high specific gravity and good internal quality. However, there are fewer tubers on reduced stem numbers compared to current commercially available varieties. This results in fewer and larger tubers, which is a concern for chip processors. Growers can manage tuber size with agronomic practices and overcome the tuber size issues if tuber quality in storage is excellent. The purpose of this bulk bin experiment was to evaluate glucose and sucrose reaction during pile cooling to 48ºF. The initial pulp temperature was 60.0ºF during loading on 10/27/21. The bins were cooled to 52ºF by early November. The original target temperature was not met, as the storage and handling committee chose to hold the bin at 52ºF and ship to a processor when the tubers reached acceptable quality.

The seed was planted in Three Rivers, MI on 4/14/21 and vine killed on 8/30/21 (138 DAP, GDD_{40} 3717). This field was harvested on 10/23/21, 192 days after planting. At loading, there were 32% bruise free with an average of 1.4 bruises per tuber.

Results

Bulk Bin 1, MSZ242-13 (GDD_{40} 3717, 48ºF)

MSZ242-13 was grown at Walther Farms, Three Rivers Michigan (Figure 7). The Potato Outreach Program conducted a test dig prior to vine kill, in which ten feet of potatoes were harvested and graded. A US#1 yield of 472 cwt/A and total yield of 514 cwt/A were calculated from this test dig. Specific gravity was 1.090. There were 6.1 tubers per plant, 1.8 tubers per stem, and an average tuber weight of 5.9 oz. There were 65% A-sized tubers, 8% B-sized tubers, 27% oversize tubers, and no pickouts (Table 6). One preharvest panel was done on 8/30/21, just before vine kill (Table 7).

The sucrose concentration in tubers sampled during bin loading was 0.608%X10, and concentrations fluctuated until the January 4th sample. Sucrose then rose sharply to a high of 1.692%X10 on February 7th, but then dropped to 0.688%X10 at the last sample on February 21st. The glucose concentrations followed a similar trend, and rose through December, fell through January, and then greatly increased on the February 7th sample. The final glucose concentration was 0.004%. Total chip defects were elevated during storage, always above 20% (Figure 8). This was due to the physical condition of the tubers, which caused rotten chips and dark chip color (Figure 10). There were 33.3% defects in the final sample on February 21st (Figure 8).

The bin was unloaded on February 24th due to severe wet breakdown (Figure 9). Tuber quality deteriorated such that a processor would not accept them. Pressure bruise and weight loss in storage data could not be calculated due to poor tuber quality.

Table 6. 2021 Chip Process Potatoes
Bulk Planting Test Digs

	CWT/A		PERCENT OF TOTAL[1]																RAW TUBER QUALITY[3] (%)				COMMON SCAB
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR[2]	Stand Count	Stem Count	Bs	As	OV	PO	Total Tubers	Tubers per Plant	Tubers per Stem	Average Tuber Weight	HH	VD	IBS	BC	RATING[4]
NY163 Sandyland Farms	562	593	95	4	64	31	1	1.083	11	35	15	66	15	2	98	8.9	2.8	6.3	0	0	0	0	0.0
Manistee Sandyland Farms	593	609	98	3	54	44	0	1.081	9	31	10	55	22	0	87	9.7	2.8	7.3	0	0	0	0	0.0
MSW474-1 Thorlund Bros.	333	456	73	27	73	0	0	1.091	10	40	78	86	0	0	164	16.4	4.1	2.9	0	0	0	0	0.5
FL2137 Thorlund Bros.	291	427	68	32	68	0	0	1.089	10	46	93	69	0	0	162	16.2	3.5	2.7	0	0	0	0	0.0
MSZ242-13 Walther Farms Three Rivers	472	514	92	8	65	27	0	1.090	15	50	25	54	12	0	91	6.1	1.8	5.9	0	0	0	0	1.5
Manistee Walther Farms Three Rivers	484	597	81	18	73	8	1	1.079	11	40	81	85	4	2	172	15.6	4.3	3.6	0	0	0	0	0.5
MEAN	**456**	**533**	**85**	**15**	**66**	**18**	**0**	**1.086**	**11**	**40**	**50**	**69**	**9**	**1**	**129**	**12.1**	**3.2**	**4.8**	**0**	**0**	**0**	**0**	**0.4**

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

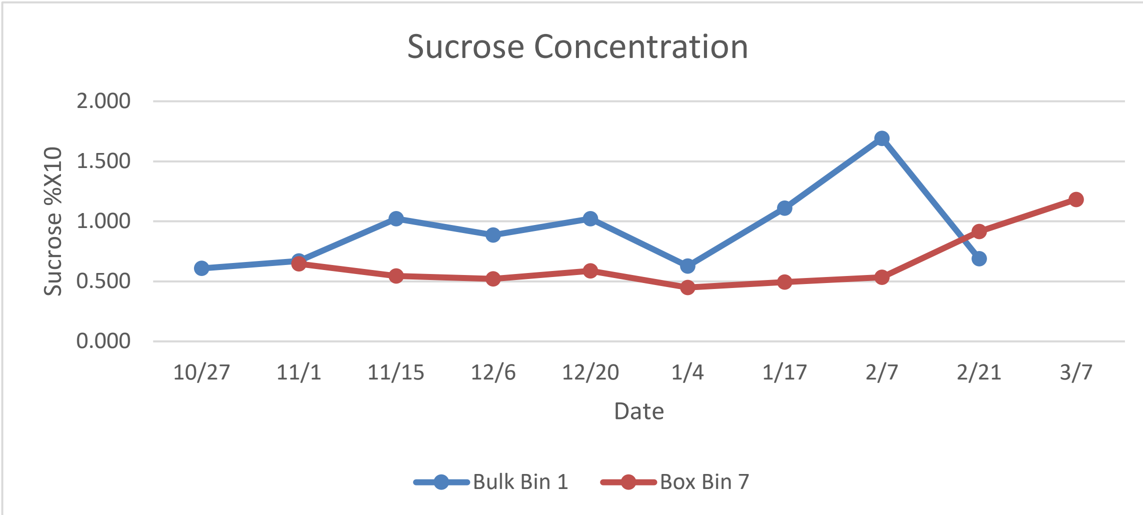
[4]**COMMON SCAB RATING**
0.0: Complete absence of surface or pitted lesions
1.0: Presence of surface lesions
2.0: Pitted lesions on tubers, though coverage is low
3.0: Pitted lesions common on tubers
4.0: Pitted lesions severe on tubers
5.0: More than 50% of tuber surface area covered in pitted lesions

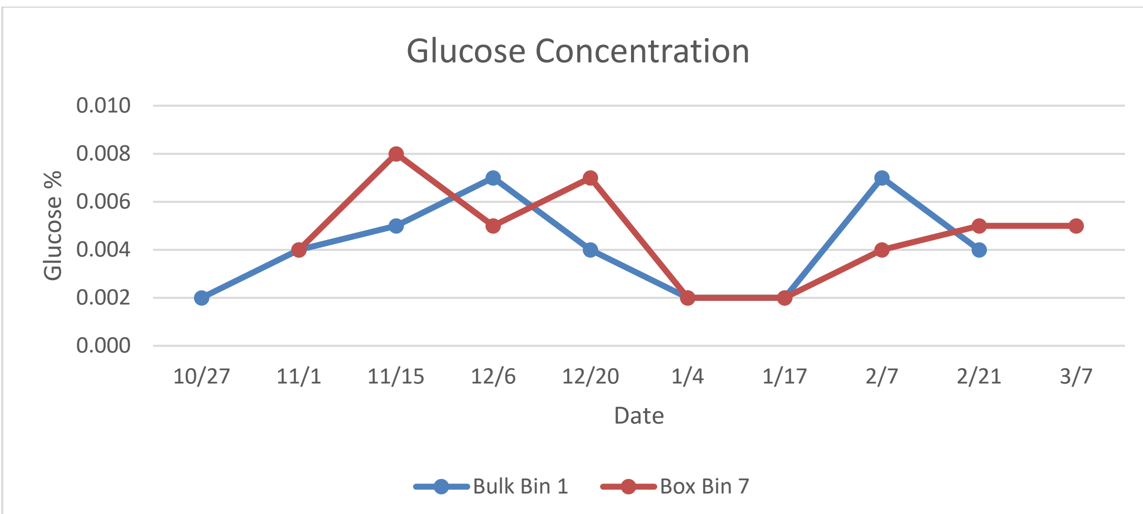
Table 7. 2021 Chip Process Potatoes
Bulk Planting Pre-Harvest Panels

LINE	Sugar Profile		Specific Gravity	Date
	Glucose %	Sucrose %X10		
MSZ242-13 Walther Farms, Bin 1	0.003	0.651		8/30/21
NY163 Sandyland Farms, Bin 2	0.003	0.514	1.084	8/18/21
MSW474-1 Thorlund Bros., Bins 3 and 4	0.003	0.651	1.088	9/1/21
Petoskey Walther Farms, Bins 5 and 6	0.002	0.654	1.086	8/17/21

Figure 7. Manistee plants (left) and MSZ242-13 plants (right), and a close up of tuber initiation, both at Walther Farms, Three Rivers MI on 6/9/21.

Figure 8. Sucrose concentration, glucose concentration, and total defects in Bin 1, Walther Farms Three Rivers MSZ242-13 compared to the same box bin variety from 2021 to 2022.





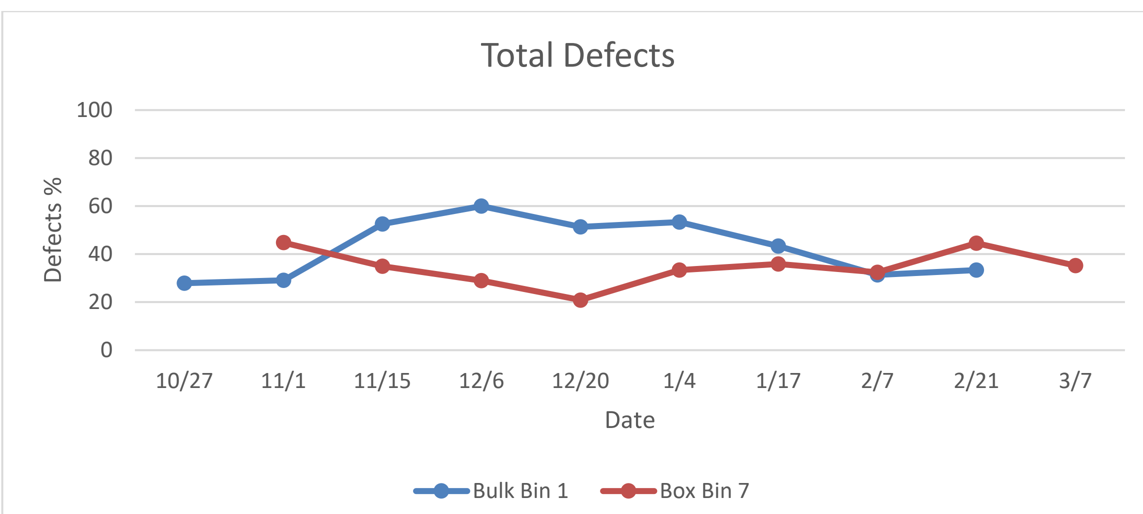


Figure 9. MSZ242-13 tubers during bin unloading on 2/24/22.

Figure 10. Bulk Bin 1 chips on the first sample date (10/27/21), sample with highest defect incidence (12/6/22), and final sample date (2/21/22).

NY163 Storage Trial (GDD_{40} 3369, 45ºF)

NY163 was developed at Cornell University and has been evaluated by the Potato Outreach Program since 2016. While the yield is typically average to below average, it has a high tuber set and a smaller tuber size profile, which is appealing to the current needs of chip processors. NY163 is tolerant to both common scab and stem end defects and has an earlier vine maturity than Snowden. The thin skin makes it attractive to chip processors. It has good fresh chip quality and long-term storage potential. Some chip blistering has occurred, so this variety may be best suited for wavy or kettle chips. At bin loading the tubers were 72% bruise free with an average of 0.4 bruises per tuber. The tubers were planted at Sandyland Farms, Howard City, Michigan on 5/11/21, and were vine killed on 9/8/21, 120 days after planting. The potatoes were harvested on 10/8/21, 150 days after planting. The pulp temperature was 64.4ºF at bin loading. The NY163 seed was planted in a field with Manistee (Figure 11).

Results

The Potato Outreach Program conducted a ten-foot test dig of NY163 (Table 6). US#1 yield was 562 cwt/A and total yield was 593 cwt/A. Unusually for the variety, there were 31% oversize tubers, and the specific gravity was 1.083. The internal quality was good with no defects observed. One pre-harvest panel was taken on 8/18/21. The glucose concentration was 0.003%, and the sucrose concentration was 0.514%X10 (Table 7). The bin was initially cooled to 48ºF at 0.4ºF per day and was further cooled to 45ºF at 0.2ºF per day. This temperature was maintained from December to bin unloading on 3/14/22.

The glucose concentrations in NY163 from October to March were variable, with a range of 0.000% (not actually 0, but a value too low to be detected by Techmark, Inc.) to 0.009% at bin unloading on 3/14/22. The sucrose concentrations were less variable, and followed a trend of increasing through January, then decreasing through bin unloading. Most samples had good chip quality, excluding three samples on 11/1/21, 1/4/22, and 2/21/22 with defects over 20% (Figure 12).

The bin was unloaded on 3/14/22 when the pile temperature was 44.8°F. The Storage and Handling committee had hoped to store NY163 until June but rising glucose concentrations made chip quality after continued storage uncertain (Figure 13). Therefore, the potatoes were unloaded (Figure 14) and sent to Herr Food for processing on 3/15/22 (Figure 15). Sackett Potatoes chipped a sample of tubers and calculated a specific gravity of 1.081 (Figure 16). Herr Foods sent a sample of unsorted chips to the Potato Outreach Program, where chips were categorized as internal defects, external defects, sugar defects, or acceptable chips (Figure 17). There were 92.3% acceptable chips and 7.7% total defects. The defects were composed of 1.8% internal, 3.5% external, and 2.4% sugar defects.

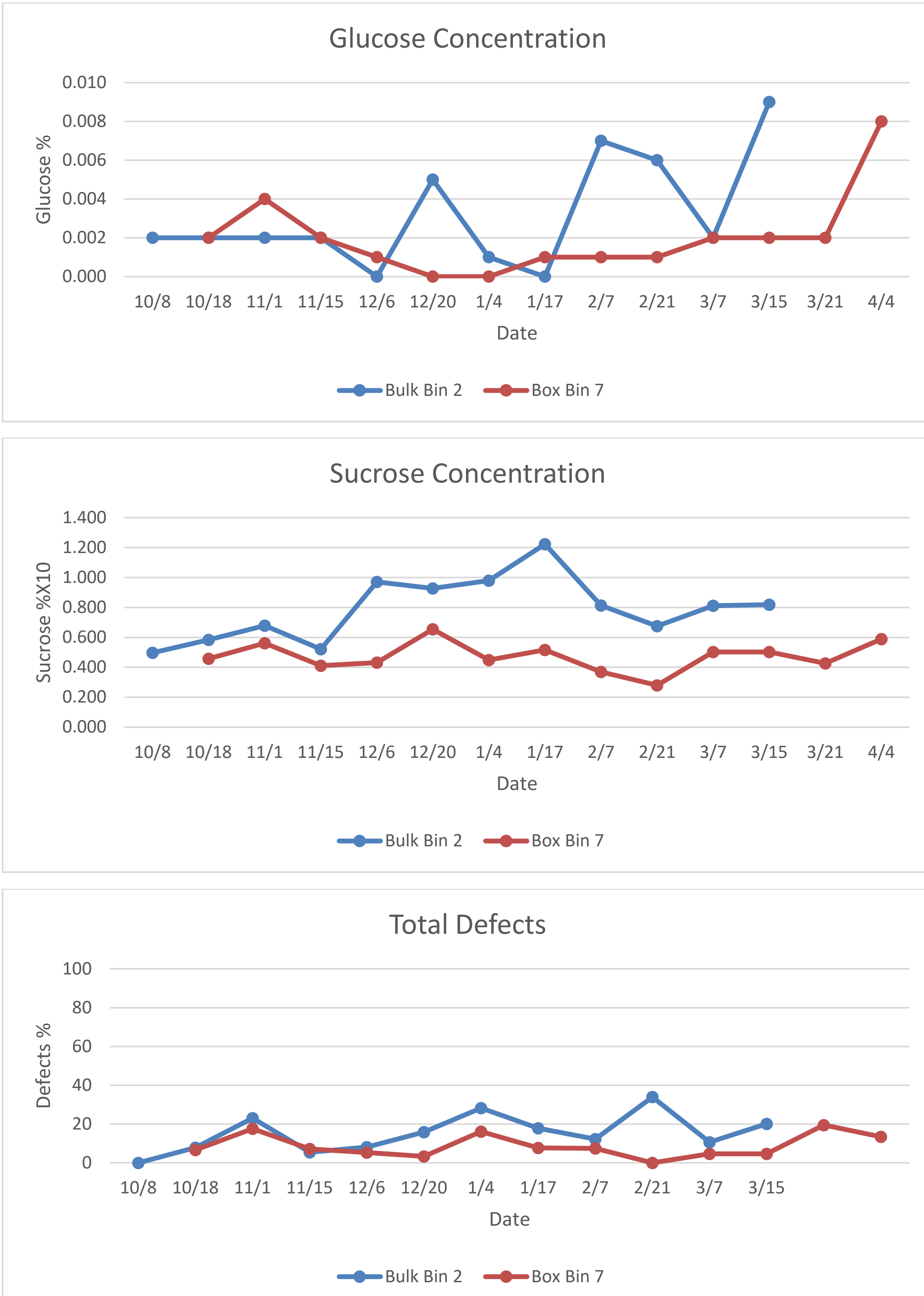
Pressure bruise evaluations were conducted on March 23rd according to the protocol described earlier in the report. Most tubers were bruised, with only 18% bruise free tubers after storage. However, most bruises did not discolor the tubers, and only 24% of the tubers had bruises with color (Table 6).

NY163 continues to exhibit many good traits that make it an Atlantic or Pike replacement for out of the field and mid-season storage. This storage season continued to demonstrate the cold chipping potential of this common scab tolerant variety. As processors move towards smaller bags of chips, the above average tuber set per plant and generally smaller tuber type continue to be attractive to the industry. Unfortunately, moderate susceptibility to storage rots, including Pink Rot, Pythium Leak, and Bacterial Soft Rot, as well as thinner skin, remain challenging for growers and processors.

Figure 11. NY163 potato plants (right) in a field with Manistee plants (left). Close up of NY163 tubers, both at Sandyland Farms, Howard City, MI on 6/29/21.

Figure 12. Glucose concentration, sucrose concentration, and total defects in Bin 2, Sandyland NY163 compared to the same box bin variety from 2021 to 2022.



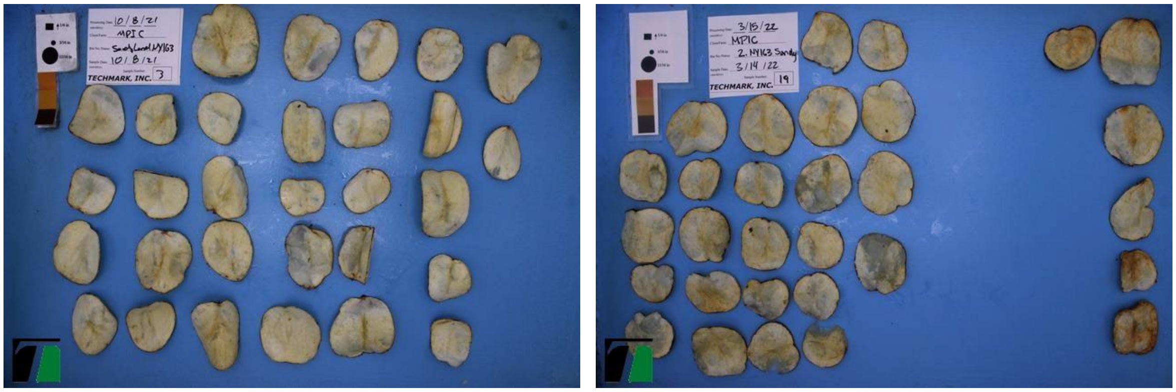


Figure 13. NY163 chips from the first (10/18/21) and last (3/14/22) sample dates.

Figure 14. NY163 tubers at bin unloading on 3/14/22.

Figure 15. Bulk Bin 2 NY163 tubers (left) and chips (right) at Herr Foods on 3/15/22.

Figure 16. NY163 chipped by Sackett Potatoes on 3/14/22.

Figure 17. NY163 chips from Herr Foods sorted by Potato Outreach Program staff.

Table 6. 2021-2022 PRESSURE BRUISE DATA
Bulk Bin #2 NY163 (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 1	3.70	11	9	5	0	45	55	0
8' Bin 1	4.16	2	6	9	8	8	83	9
3' Bin 1	8.63	0	1	7	16	1	37	61
OVERALL AVERAGES	**5.50**					**18**	**58**	**24**

[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	10/8/2021	Pulp Temp. (at Filling)	64.6ºF		
Unloaded	3/14/2022	Target Storage Temp.	45ºF	End Temp.	44.8ºF

MSW474-1 Storage Trial (Bins 3 and 4)

This Michigan State University variety has continued commercialization potential in Michigan due to an above average specific gravity, common scab resistance, May storability from 46ºF, and a vine maturity similar to or later than Snowden. The yield potential continues to be lower than that of Snowden, and MSW474-1 displays variable chip quality in early storage with a higher proportion of chip defects when processed out of the field.

These two bulk bins were filled with potatoes grown by Thorlund Brothers in Greenville, MI in a field with Manistee potatoes (Figure 17). The Potato Outreach Program conducted a ten-foot test dig prior to vine kill and calculated 333 cwt/A US#1 yield and 456 cwt/A total yield. The specific gravity was 1.091 and no internal defects were observed. There were 16.4 tubers per plant and 4.1 tubers per stem. The average tuber weight was 2.9 ounces. The tuber size profile was 73% A-sized tubers, 27% B-sized tubers, and no oversize or pickout tubers. Given the high tuber set and proportion of undersized tubers, a wider seed spacing of 12 to 13 inches may optimize yield. The potatoes in both bins were planted on April 26th and vines were killed on September 4th (131 DAP, GDD_{40} 3436). Harvest occurred on October 27th, 184 days after planting. Two pre-harvest panels were conducted on August 18th and September 1st. Stable glucose and increasing sucrose indicates potential chemical immaturity prior to vine kill. At harvest the pulp temperature was 53ºF for both bins. The tubers were damaged at bin loading, with 12% bruise free tubers in Bin 3 and 20% bruise free tubers in Bin 4. The bins were loaded the day of harvest and were treated with CIPC on November 16th and February 16th. These bins were designed to study chip quality and potato storability under two different storage protocols.

Figure 17. MSW474-1 potatoes (right) with Manistee potatoes (left) at Thorlund Brothers on 6/29/21.

Results

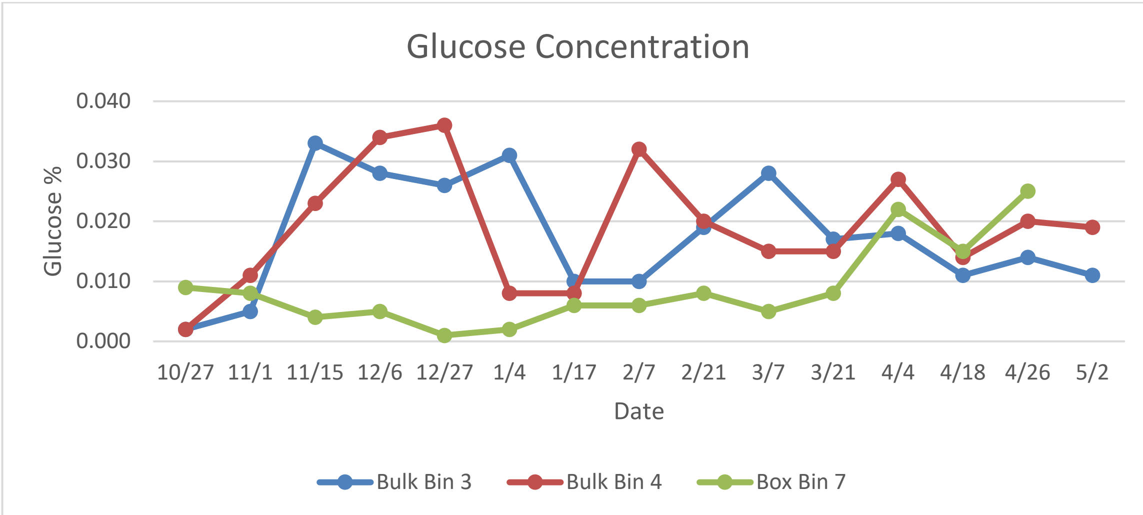
Bulk Bin 3, MSW474-1 (GDD_{40} 3436, 46ºF)

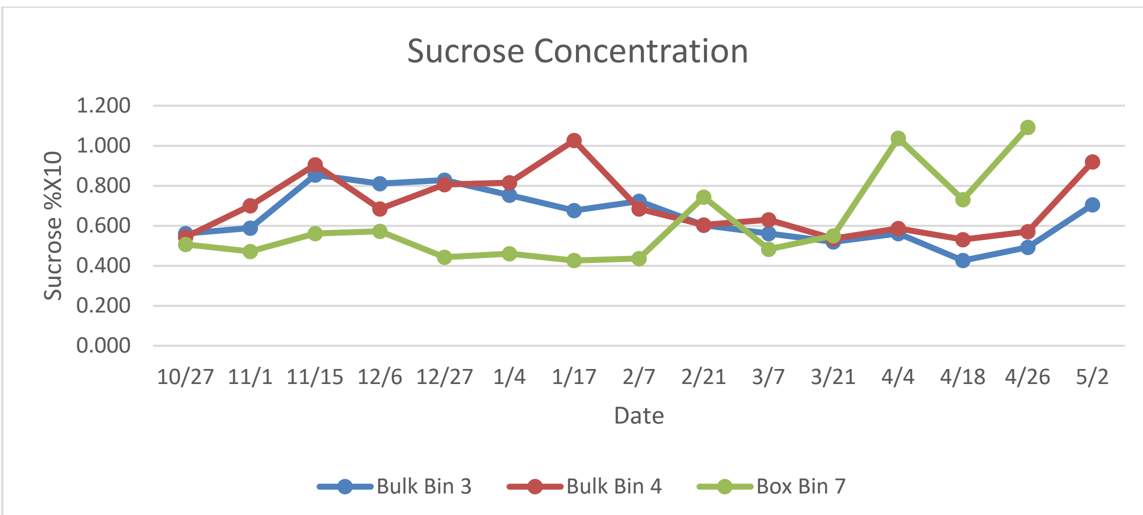
This bin was cooled from 54ºF to 50ºF by mid-November by cooling at a rate of 0.4ºF per day and was further cooled to 48ºF at 0.2 ºF per day through December. The initial target temperature was 46ºF, but high free sugars contraindicated further cooling beyond 48ºF. Beginning in April the temperature increased and ended at 52.8 ºF at bin unloading on May 2nd. MSW474-1 displayed a stable but generally decreasing sucrose concentration. The sucrose trended down from bin loading through later April, after which it rose until bin unloading in early May. Glucose concentrations were more variable, with concentrations above 0.025% from November to January. Concentrations were again high on March 7th at 0.028% but were below 0.020% at all other samples. The variable glucose indicates that higher free sugars were present in the tubers at several points in the storage season. While the sugar was metabolized, indicated by the more stable sucrose, the MSW474-1 chip samples would have produced more brown chips had the storage temperature been further reduced to the original target temperature of 46ºF. Total defects were variable, with defects between 0% and 91.8%. All but three samples at the beginning of storage had over 25% defect incidence (Figure 18).

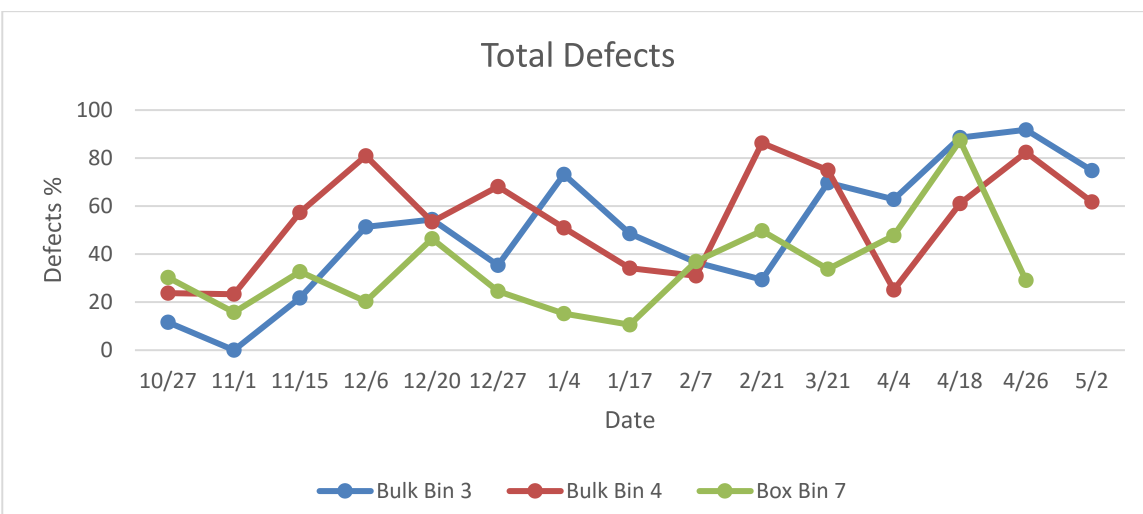
Raising the temperature of the bin from April to May was an attempt to recondition the potatoes and prevent further starch to sucrose conversion. Unfortunately, two samples (April 26th and May 2nd) indicated that reconditioning was unlikely to succeed. At bin unloading, the potatoes in Bin 3 were sold to Campbells Soup Company. No further process data is available.

At bin unloading, most tubers had bruises. This was expected, given that only 12% were bruise free at bin loading. However, 87% of the tubers were bruised with no color, indicating that the bruises were less likely to negatively impact chip quality by causing discoloration in finished chips (Table 7).

Figure 18. Glucose concentration, sucrose concentration, and total defects in Bins 3 and 4 Thorlund MSW474-1 compared to the same box bin variety.







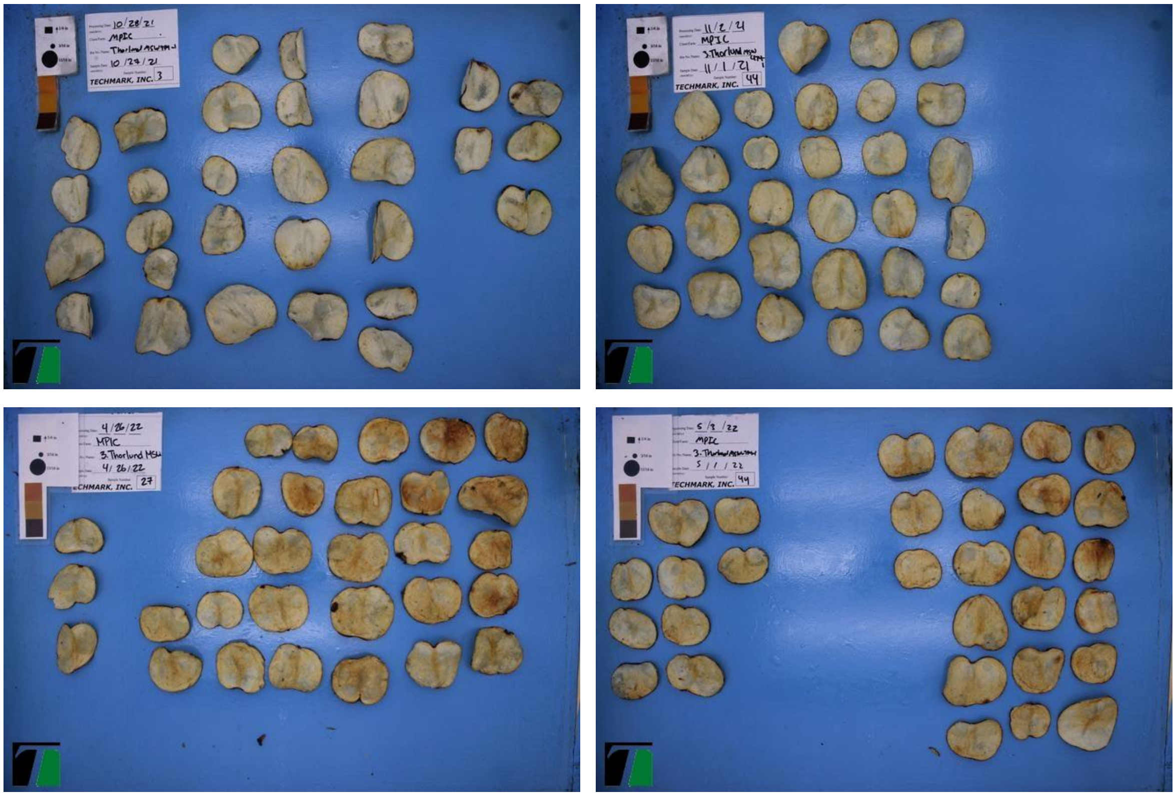


Figure 18. MSW474-1 chip images on 10/27/21 (top left), 11/1/21 (top right), 4/26/22 (bottom left), and 5/2/22 (bottom right).

Bulk Bin 4, MSW474-1 (GDD$_{40}$ 3436, 48ºF)

This bulk bin was cooled like Bin 3 above and reached the target temperature of 48ºF by December. No further cooling was attempted, as Bulk Bins 3 and 4 were initially filled to observe differences in chip quality between tubers stored at 46ºF and 48ºF. The sucrose concentrations in Bin 4 were more variable than those of Bin 3. While concentrations were stable to decreasing in Bin 3, they rose from the beginning of storage to January, when they reached a high of 1.026%(X10). After this date, sucrose generally decreased with each sample. The rise in sucrose from April 26th to the end of storage indicates higher reducing sugars and decreased chip quality.

Glucose concentration in Bin 4 was also variable, with the highest concentration of 0.037% observed on December 27th. As in Bin 3, these concentrations were higher than those of the

Thorlund MSW474-1 tubers kept in the Box Bin trial at 54ºF. Three chip samples had defects over 80%, December 6th, February 21st, and April 26th. All other chip samples had defects over 20%.

Declining chip quality and rising sucrose necessitated the sale of the potatoes in Bin 4 on the same date as Bin 3. No additional processor data is available. The pressure bruise evaluation produced similar results to that of Bin 3. Only 4% of tubers were bruise free, but 78% of tubers that did have bruising did not have discoloration. 18% of tubers were bruised with color, higher than the 2% in Bin 3.

There is continued processor interest in further evaluating MSW474-1 given its many strong agronomic qualities. The storage and handling committee had concerns of variable maturity in the field at harvest. Potential chemical immaturity may have played a role in poor storage quality from 2021 to 2022.

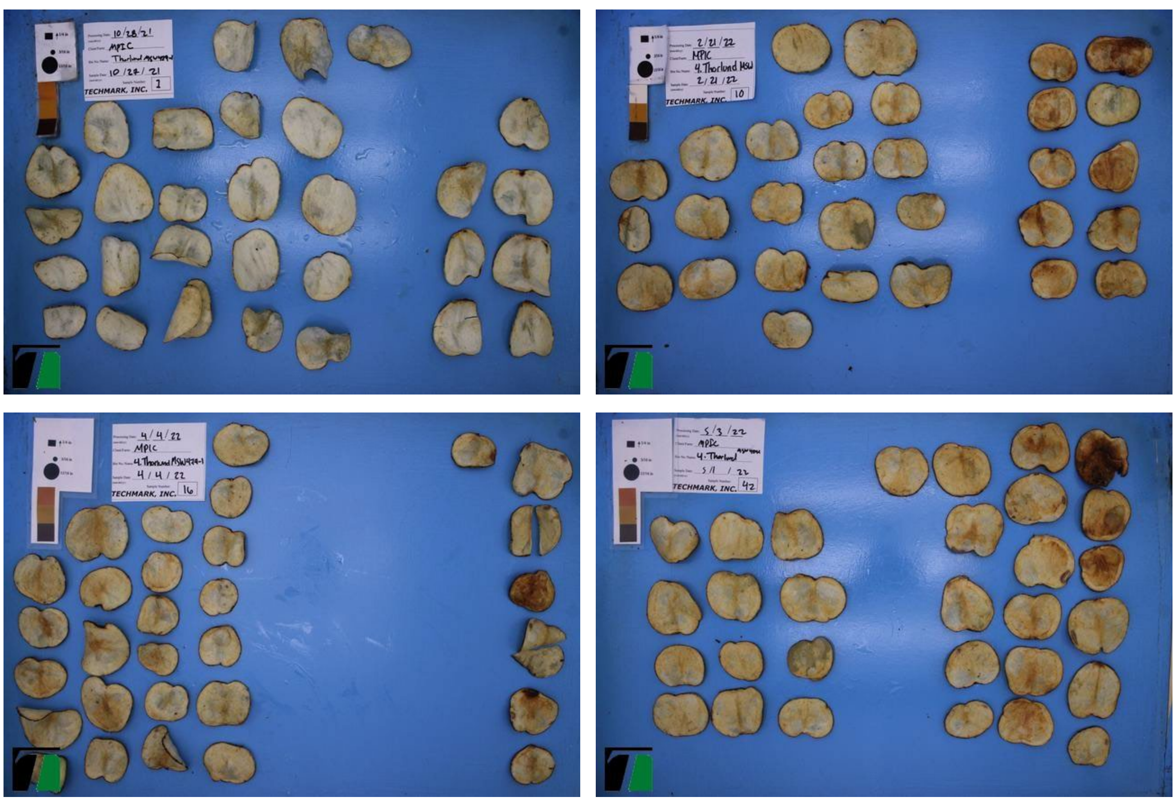


Figure 19. MSW474-1 from Bin 4 chip samples taken on 10/27/21 (top left), 2/21/22 (top right), 4/4/22 (bottom left), and 5/2/22 (bottom right).

Table 7. 2021-2022 PRESSURE BRUISE DATA Bulk Bin #3 and #4 MSW474-1 (Greenville, 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 3	22.06	3	7	9	6	11	88	1
8' Bin 3	20.59	3	12	8	2	11	85	4
3' Bin 3	22.13	3	11	7	4	12	88	0
OVERALL AVERAGES	**21.59**					**11**	**87**	**2**
14' Bin 4	20.10	2	14	6	2	8	85	7
8' Bin 4	20.78	1	6	10	8	4	81	15
3' Bin 4	22.57	0	1	4	19	0	68	32
OVERALL AVERAGES						**4**	**78**	**18**

[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	10/27/21(both)	Pulp Temp. (at Filling)	53.0ºF (both)		
Unloaded	5/4/22 (both)	Target Storage Temp.	46.0ºF (3) 48.0 ºF (4)	End Temp.	52.8ºF (3) 53.0ºF (4)

Petoskey (Bins 5 and 6)

This Michigan State University selection has been evaluated by the Potato Outreach Program since 2016. It has an above average specific gravity, common scab resistance, vine maturity like that of Snowden, and can be stored until May at 46ºF. However, the yield potential is typically less than that of Snowden and it may display a post emergence herbicide stress response. Petoskey is not suited for shipping from early storage, but chip quality typically improves after four months in storage. The tuber shape is round to occasionally slightly compressed with a heavier netted skin.

This variety was planted on April 10th at Walther Farms, Cass City MI with a 9.5 inch in row spacing. Vine kill occurred on September 3rd (146 DAP, 3702 GDD_{40}). The potatoes were harvested on September 20th (163 DAP, 4146 GDD_{40}). At harvest, the pulp temperature was 63.6ºF, and at bin loading the pulp temperature was 61.2ºF in Bin 5 and 62.8ºF in Bin 6. Tubers were 44% and 52% bruise free, with 0.9 and 0.7 bruises per tuber, respectively.

One pre-harvest sample was taken for Petoskey on August 17th (Table 7). The specific gravity was 1.086, glucose was 0.002%, and the sucrose rating was 0.645% (X10). The sample was chipped and had an SFA color of 1.0 with some bruising noted. Both bins 5 and 6 were gassed with DMN and CIPC on November 16th and February 16th.

Figure 20. Petoskey (left) and Lamoka (right) grown at Walther Farms Cass City on 6/22/21, 73 days after planting with 1430 GDD_{40}

Figure 21. Close up of Petoskey tubers at Walther Farms Cass City on 7/19/21, 100 days after planting with 2254 GDD_{40}

Results

Bulk Bin 5, Petoskey (GDD_{40} 3702, 48ºF)

The target temperature in Bulk Bin 5 was achieved by November 11th through cooling from 52ºF to 48ºF at 0.4ºF per day. This temperature was maintained until bin unloading on March 15th.

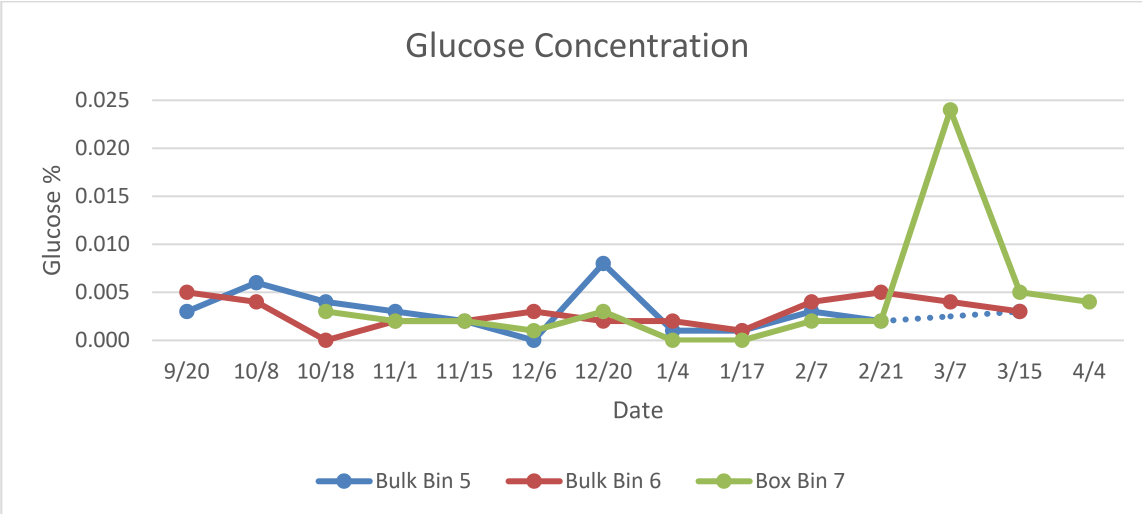
The sucrose concentration was initially high at 1.189% (X10) but decreased through November during initial bin cooling. The concentrations fluctuated until early February, then decreased to 0.363% (X10) at bin unloading. Glucose concentrations were more stable and decreased from bin loading until early December. The glucose was highest at 0.008% on December 20th, but then decreased to 0.003% at the end of storage. Petoskey had variable chip defects, with all samples containing between 10% and 30% defects from bin loading until December. Defects then increased above 40% for the next three samples, before chip quality increased for the final three evaluations. No sample was taken on March 7th, but the final sample had 15.7% defects (Figure 22). Bruise, slight stem end color, and dark chips caused chip defects in Bin 5. A dashed line is used between the 2/21/22 and 3/15/22 data points to estimate the missing data series.

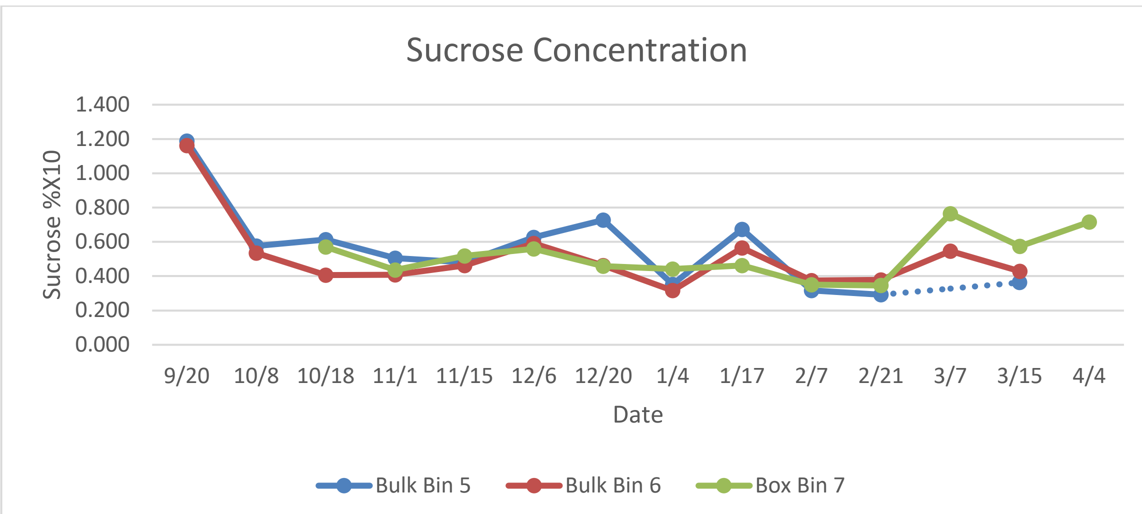
Both Bin 5 and Bin 6 were unloaded on 3/15/22 when rising chip defects indicated that the variety would not likely store until April or May as was initially planned (Figure 24). At unloading, some internal sprouting was observed, confirming that chip quality would not improve with additional storage (Figure 25). Both bins were shipped to Middleswarth Potato Chips, Middleburg, PA. A sample of tubers was also processed by Sackett Potatoes, Mecosta MI (Figure 26). The specific gravity was 1.081 and Frito Lay solids was 16.94.

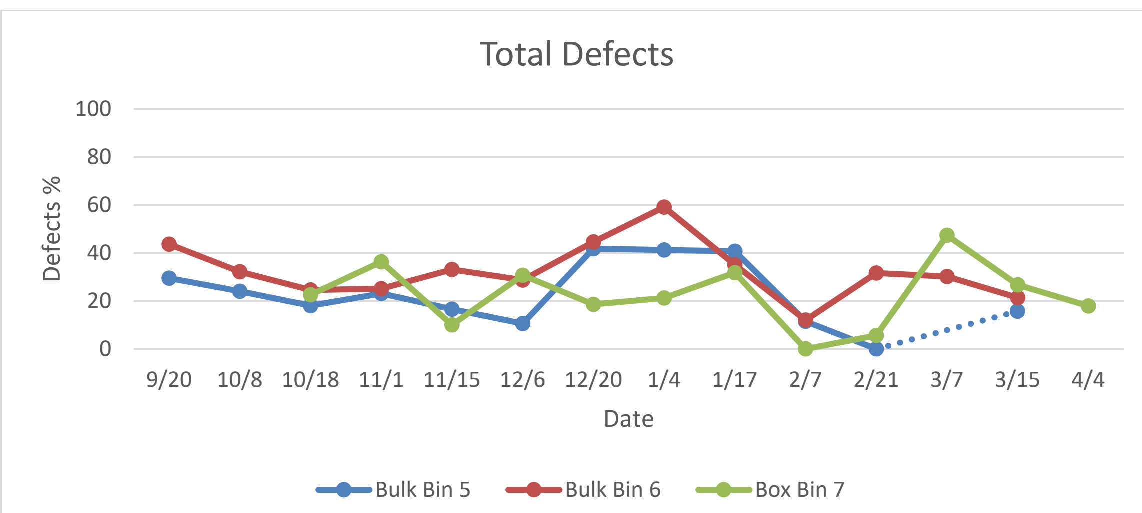
A sample of cooked chips from Middleswarth Potato Chips was sent to East Lansing MI for evaluation by Potato Outreach Program staff. There were 90.38% acceptable chips, 9.22% of chips with external defects, mainly due to sprouting, and 0.39% of chips with internal defects (Figure 27).

Average weight loss was 4.27% with 26% bruise free tubers. 54% were bruised with no color, and only 20% were bruised with color (Table 8).

Figure 22. Glucose concentration, sucrose concentration, and total defects in Bins 5 and 6 Walther Petoskey compared to the same box bin variety







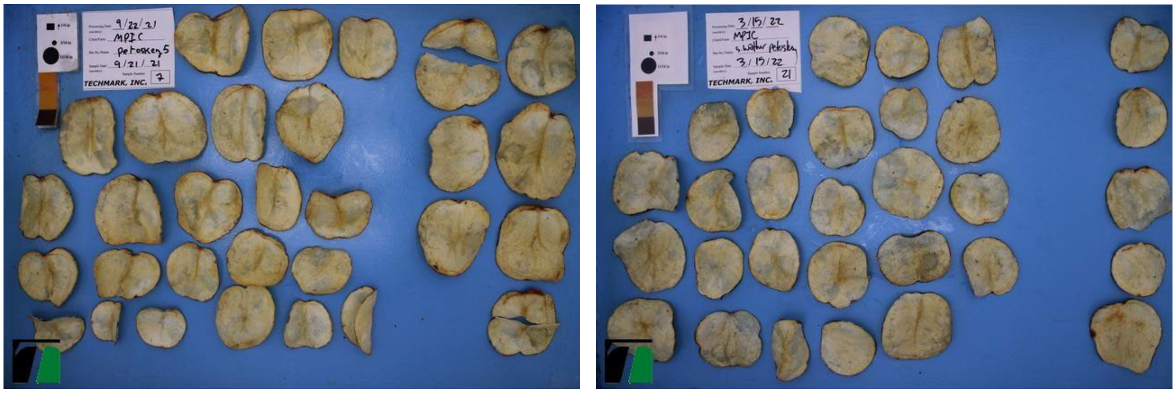


Figure 23. Bulk bin 5 first chip sample on 9/20/21 (left), and last chip sample on 3/15/22 (right).

Figure 24. Petoskey tubers in Bin 5 at unloading on 3/15/22.

Figure 25. Some internal sprouting was observed in the Petoskey tubers at bin unloading (left), with a section cut off the tuber (right) on 3/15/22.

Figure 26. Tubers from Bin 5 were chipped by Sackett Potatoes on 3/15/22.

Figure 27. Chips from Middleswarth Potatoes Chip after sorting by defect type. Acceptable chips are on the left, chips with internal defects are on the top right, and chips with external defects are on the bottom right.

Bulk Bin 6, Petoskey (GDD$_{40}$ 3702, 50ºF)

This bin performed like Bin 5 in terms of total chip defects, internal color, and undesirable color. Sucrose followed a generally decreasing trend at each sample but was slightly lower than the sucrose concentration in Bin 5. Glucose concentration was consistent with that of Bin 5, ending at 0.002% at bin unloading on November 30th. There was one incidence of undesirable color on November 16th, 8.6%. Internal color was always above nine percent, with the highest incidence in the first sample. Total defects were also elevated, with each sample containing over 33% defects.

This bin was also unloaded on November 30th. As the tubers from Bin 5 and Bin 6 were mixed for processing, no separate data exists for Bin 6. See Bin 5 for results from Better Made Snack Foods. Sackett Potatoes processed a sample from Bin 6 on November 30th and found a specific gravity of 1.077 and Frito lay Solids of 16.2 (Figure 33). Average weight loss in Bin 6 was 2.22%. 83% of tubers were bruise free, 16% were bruised with no color, and one percent was bruised with color (Table 8).

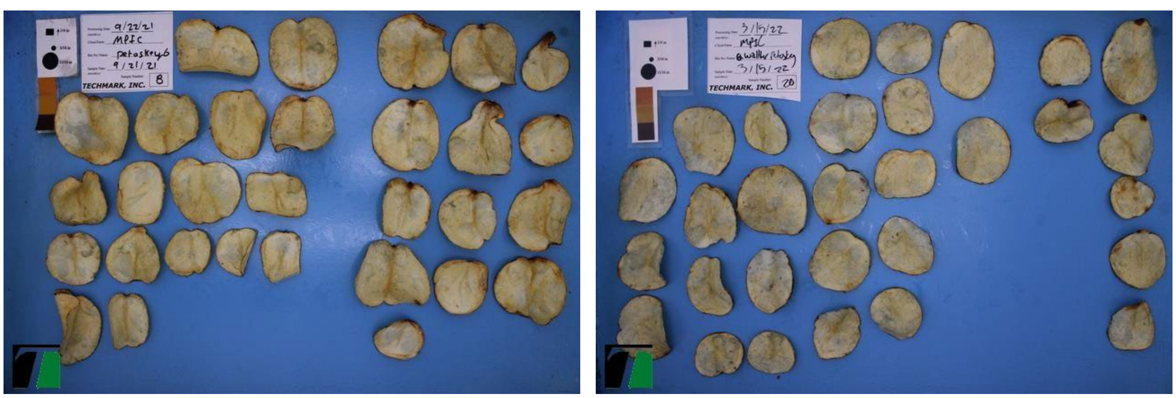


Figure 28. Bulk Bin 6 first chip sample on 9/21/21, and last chip sample on 3/15/21.

Figure 29. Unloading Bin 6 on 3/15/22.

Figure 30. Chips made at Sackett Potatoes from Bin 6 tubers on 3/15/22.

Figure 31. Chips from Middleswarth Potato Chips sorted by the Potato Outreach Program on 7/27/22. Acceptable chips are on the left side, with external, vascular, internal, and greening defects in descending order on the right side.

Table 8. 2021-2022 PRESSURE BRUISE DATA Bulk Bin #5 and #6 Petoskey (Cass City, MI)								
Location[1]	Average Weight Loss (%)	Average Number of External Pressure Bruises Per Tuber[2]				Average % of Total Tuber Number		
		0	1	2	3+	Without Bruise	Bruised (No Color)	Bruised with Color[3]
14' Bin 5	4.45	11	7	5	1	44	52	4
8' Bin 5	468	6	10	7	2	24	56	20
3' Bin 5	3.67	2	9	9	5	9	55	36
OVERALL AVERAGES	**4.27**					**26**	**54**	**20**
14' Bin 6	8.17	14	9	2	0	55	43	3
8' Bin 6	4.12	8	13	3	1	33	64	3
3' Bin 6	4.88	9	13	3	0	37	61	1
OVERALL AVERAGES	**5.72**					**42**	**56**	**2**

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

Loaded	9/21/21(both)	Pulp Temp. (at Filling)	61.2ºF (5) 62.8ºF (6)		
Unloaded	3/15/22 (both)	Target Storage Temp.	48.0ºF (both)	End Temp.	47.8ºF (5) 48.4ºF (6)

Mackinaw Storage Pathology Trial (Bins 8 and 9)

Dr. Jaime Willbur used Bins 8 and 9 to study Mackinaw performance after a stressful growing season in 2021 and evaluated the disease susceptibility to various storage pathogens. Commercial applications of SaniDate were also evaluated as a method of reducing storage disease incidence. For further information on the pathology results from this study, please see the research report from the Willbur lab. This report deals with storge and chip quality.

The potatoes for bins 8 and 9 were grown at Sackett Potatoes, Mecosta, MI. The field was planted on May 4th, 2021, and vines were killed on September 10th (129 DAP, 3457 GDD_{40}). Tuber were harvested on October 15th (164 DAP, 4248 GDD_{40}) and had a harvest pulp temperature of 57F. One pre-harvest panel was taken on August 13th, 28 days prior to vine kill. At this time, the specific gravity was 1.099, glucose was 0.001%, and sucrose concentration was 1.195 (X10). The sample was chipped at Techmark and has a SFA color of 1.0 and 5.5% total defects.

Results

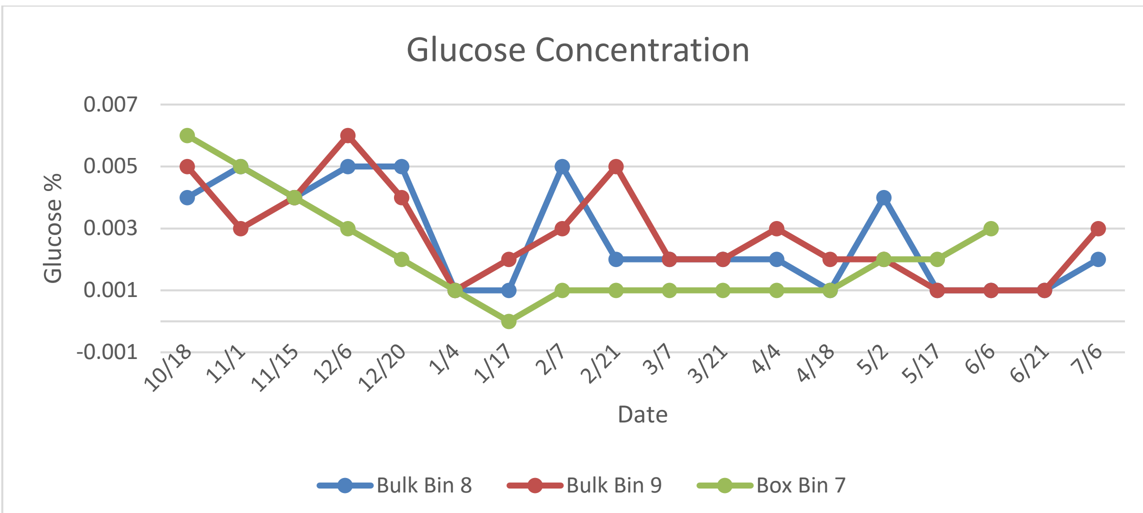
Bulk Bins 8 and 9, Mackinaw, (GDD_{40} 4248, 48ºF)

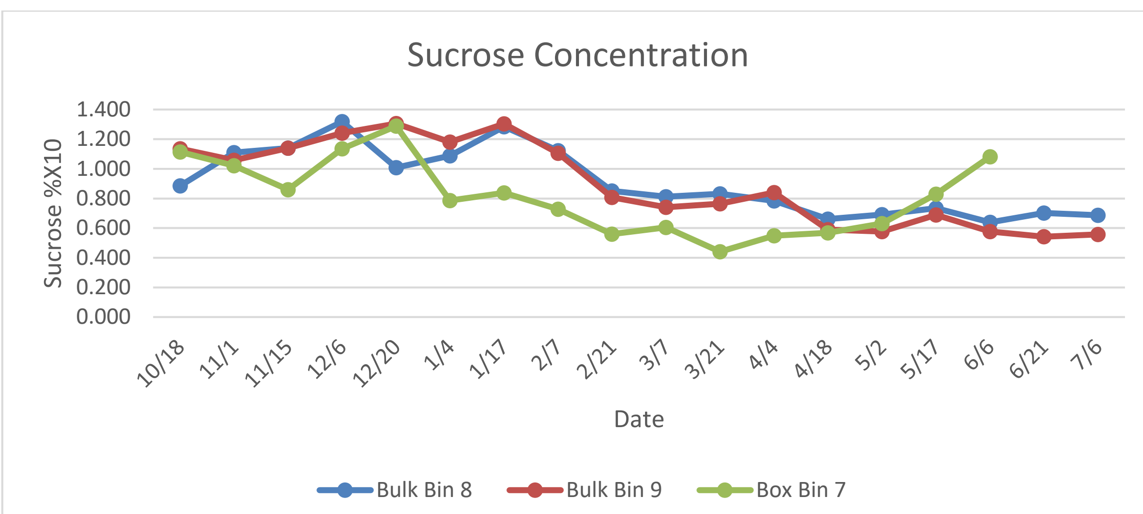
Results from Bins 8 and 9 are discussed together as the tubers were grown in the same field and both bins had the same management strategy. Bulk Bins 8 and 9 were loaded on October 16th and cooled to the target temperature of 48ºF by December, where it remained for the duration of storage (Figure 34). CIPC was applied on November 16th and February 16th. Sucrose concentrations remained elevated during storage in both bins. Bulk bins 8 and 9 had sucrose concentrations above 0.008%X10 until late February, with concentrations generally decreasing through the end of storage on July 6th. Glucose concentrations fluctuated, with values between 0.001% and 0.006% (bin 9) and 0.005% (bin 8). Total defects were variable during storage and were generally lower in bin 9. Bin 9 had the highest total defect incidence of 49.9% total defects in early May. Bin 8 had the highest total defect incidence of 35.4% in early March (Figure 34). No pressure bruising was conducted on this bin. See Figures 35 and 36 for images of the first and last chip sample in each bin.

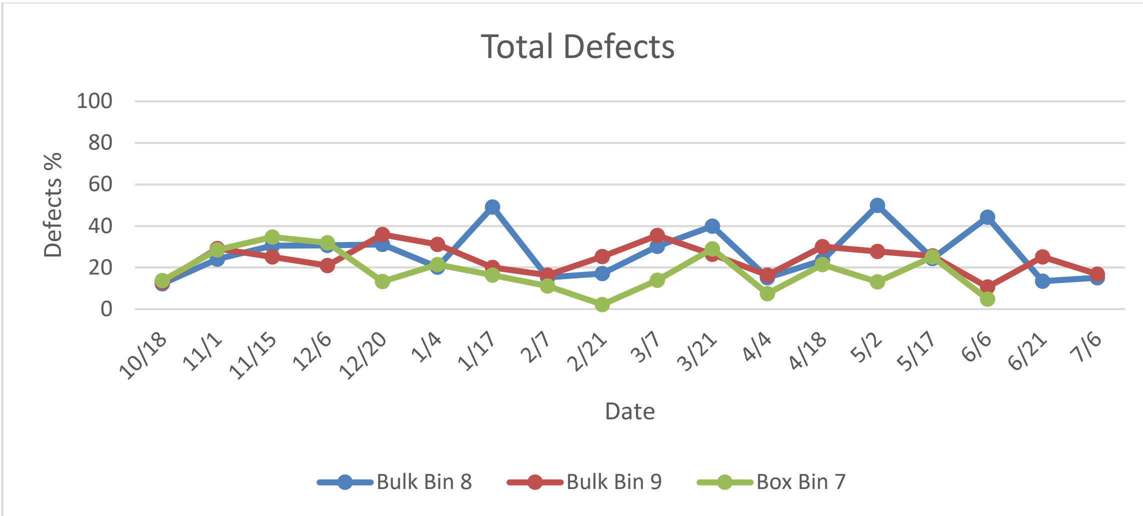
Both bins were unloaded on July 6th (Figures 37 and 38). Final bin temperatures were 49ºF for Bin 8 and 49.2ºF for Bin 9. During bin unloading, a representative sample of tubers from each bin was evaluated by Sackett Potaotes. Tubers from Bin 8 had a specific gravity of 1.088 and 18.17 Frito-Lay solids. Tubers from Bin 9 had a specific gravity of 1.089 and 18.19 Frito Lay solids. POP staff photographed the chip samples at the MSU Agronomy farm (Figures 39 and 40).

The tubers were shipped to Shearer's Food Inc., and were chipped on July 7th. Tubers from each bin were chipped as flat chips and wavy chips (Figures 41 and 42). Bin 8 produced chips with 11% total defects and an Agtron score of 58.6. Chips from Bin 9 had 12% total defects and an Agron score of 62. Shearer's Food Inc. found the chip quality acceptable and accepted both loads.

Figure 34. Glucose concentration, sucrose concentration, and total defects in Bins 8 and 9 Sackett Mackinaw compared to the same box bin variety







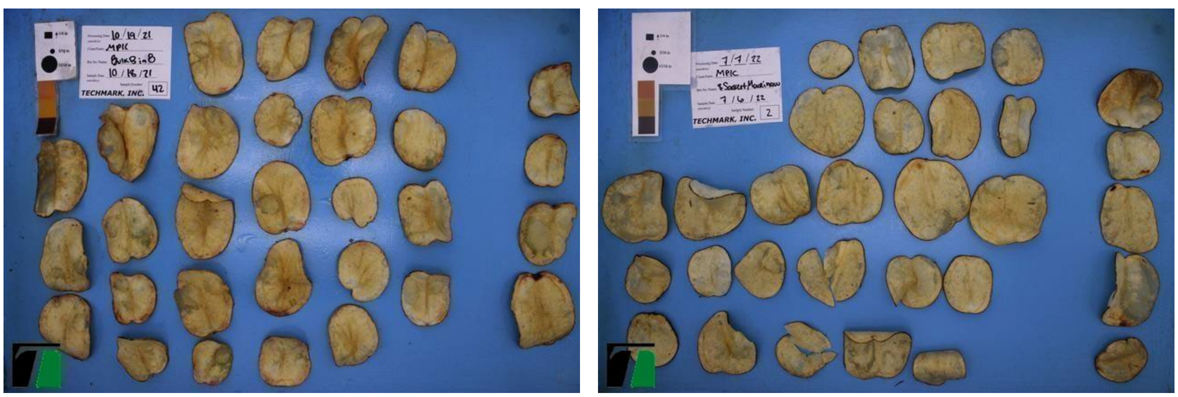


Figure 35. Bulk Bin 8 first chip sample on 10/18/21 and last chip sample on 7/6/22.

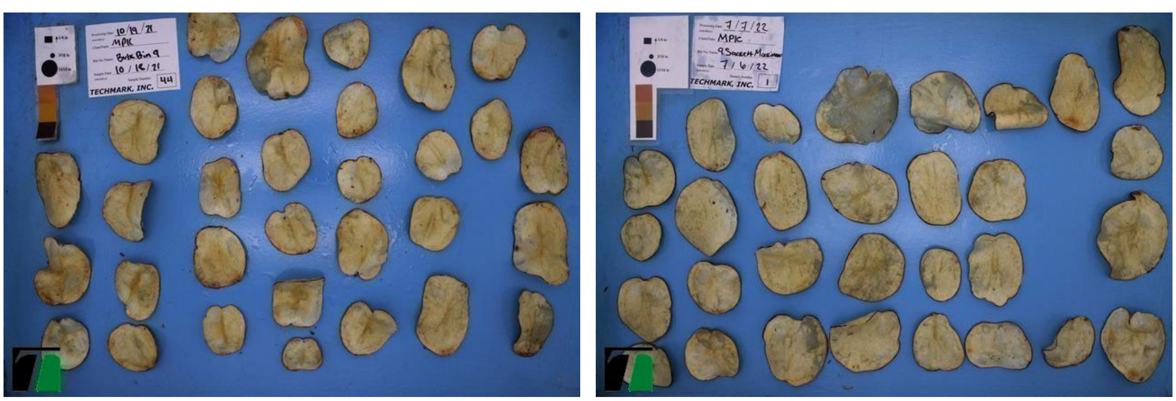


Figure 36. Bulk Bin 9 first chip sample on 10/18/21 and last chip sample on 7/6/22.

Figure 37. Tubers from Bulk Bin 8 unloading on 7/6/22.

Figure 38. Tubers from Bulk Bin 9 unloading on 7/6/22.

Figure 39. Chips produced at Sackett Potatoes from Bin 8 on 7/6/22.

Figure 40. Chips produced at Sackett Potatoes from Bin 9 on 7/6/22.

Figure 41. Flat and wavy chips produced by Shearer's Food Inc. on 7/7/22 with tubers from Bin 8.

Figure 42. Flat and wavy chips produced by Shearer's Food Inc. on 7/7/22 with tubers from Bin 9.