Michigan State University
AgBioResearch

In Cooperation With
Michigan Potato
Industry Commission

Michigan Potato Research Report
Volume 57
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December 11, 2025

Dear Members of the Michigan Potato Industry,

The Michigan Potato Industry Commission remains steadfast in its commitment to advancing potato production through dedicated research efforts. Over the past year, the Commission has provided over $212,000 in direct funding to support research projects aimed at addressing critical challenges and opportunities in our industry. These projects have delivered significant insights into areas such as variety development, disease management, soil fertility, and storage innovations—ensuring that Michigan continues to lead as a competitive and respected force in the national potato industry.

The enclosed research report reflects the collective achievements of the 2025 potato research projects, carried out with the expertise and collaboration of Michigan State University AgBioResearch and Michigan State University Extension. We are proud to share these findings, which highlight our industry's resilience, innovation, and dedication to continuous improvement. We believe these research outcomes provide valuable tools and knowledge that can be directly applied to enhance your operations. Whether refining production techniques or improving resource efficiency, the insights from these projects aim to strengthen the profitability and sustainability of Michigan potato production.

This year's research accomplishments were made possible through the dedication of our researchers, industry partners, and suppliers, whose cooperation and support have been instrumental in overcoming challenges and seizing opportunities. As we navigate an ever-evolving landscape, we are inspired by the collaborative spirit within our industry and the shared commitment to a thriving future.

We invite you to explore this report and hope it serves as a resource for your continued success. Thank you for your ongoing contributions to Michigan's potato industry and for your commitment to excellence.

Sincerely,

Kelly Turner

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

2025 MICHIGAN POTATO RESEARCH REPORT

C. M. Long, Coordinator

INTRODUCTION AND ACKNOWLEDGMENTS

The 2025 Potato Research Report contains reports of the many potato research projects conducted by Michigan State University (MSU) potato researchers at several locations. The 2025 report is the 57th 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 go 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 Phabian Makokha, MSU for organizing and compiling this final draft.

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Prologue

The following sections of the 2025 Potato Research Report present research findings from MSU's core potato research programs, reflecting a coordinated and multidisciplinary effort to address the production challenges and opportunities facing Michigan's potato industry. These programs encompass outreach and extension, plant breeding and genetics, nematology, integrated potato disease management, soil health, crop physiology, and irrigation management.

Each report has been prepared by the respective principal investigator and summarizes objectives, methods, and key findings from research conducted during the 2025 season. Collectively, these studies provide science-based information to support sustainable potato production, improve yield and quality, enhance environmental stewardship, and strengthen the long-term competitiveness of Michigan's potato industry.

Together, these program reports form the foundation of this annual volume and highlight MSU's continued commitment to collaborative, industry-driven potato research.

Potato Outreach Program

Program Objectives

The primary objectives of this program are to: (1) identify and advance promising potato breeding lines for continued testing and evaluation; (2) conduct large-scale agronomic and processing evaluations under grower-managed, commercial production systems to assess field performance and processing potential; and (3) utilize trial-derived data to support and accelerate the commercialization of new potato varieties.

The program also does research on key priorities of the Michigan Potato Industry Commission, focusing on improving potato cropping systems.

On-farm Evaluation of Agronomic and Processing Traits of Potato Genotypes

Funding: Federal Grant, MPIC and Potatoes USA/SNAC

Chris Long, Phabian Makokha, Azamat Sardarbekov, Bernard M. Schroeter, Dave Douches, James DeDecker

Materials and Methods

A total of 121 potato genotypes were evaluated across multiple locations: 28 fresh chipping lines at three sites (Table 1), 38 storage chipping lines at seven sites (Table 2), eight storage SNAC lines at one site (https://potatoesusa.medius.re/), 24 tablestock yellow-fleshed genotypes (6 advanced lines and 18 European varieties) at seven sites, two tablestock white-fleshed lines at seven sites, and seven red-fleshed lines at seven sites (Table 3), and 20 tablestock russet lines at nine sites (Table 4). All trials were conducted as non-replicated single strips, except for three trials: a storage chip trial at Walthers, a tablestock russet trial at Walthers, and a tablestock red, white, and yellow trial at Walthers. Storage evaluations were performed at the MSU Montcalm Research Center in the Michigan Potato Industry Commission storage facility during 2024–2025.

Results

Site-specific trial results are available at https://msupotato.medius.re/. Storage evaluation results are summarized in the following pages.

Table 1: Statewide Fresh Chip Processing Trials: Summary Across Three Locations, MI, 2025

LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	OTF CHIP SCORE[3]	RAW TUBER QUALITY[4] (%)				COMMON SCAB RATING[5]	SED SCORE[6]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
	US#1	TOTAL	US#1	Bs	As	OV	PO			HH	VD	IBS	BC					
AF5933-4[c]	674	741	91	9	91	0	0	1.075	1.0	0	40	0	0	2.5	0.4	1.0	2.5	mishapes, uniform round oval blocky tubers, light skin appearance
MSFF038-3[ac]	672	730	92	7	92	0	2	1.072	1.0	0	0	5	5	1.8	0.0	1.0	2.3	flat round oval, medium netted, slight skinning, sheep nose, uniform tuber type
MSHH018-3[ac]	671	727	93	8	93	0	0	1.070	1.3	0	5	0	0	0.5	0.1	1.3	2.5	blocky uniform, medium netted, slight skinning, nice general appearance
Paige[c]	636	737	86	11	86	0	2	1.081	1.0	0	10	0	10	2.0	0.0	1.0	3.0	flat oval, dark uniform type, sticky stolons, medium netted, moderate skinning
Manistee[b]	**612**	**681**	**90**	**10**	**90**	**0**	**0**	**1.080**	**1.5**	**0**	**0**	**0**	**0**	**0.5**	**0.0**	**2.0**	**3.0**	**flat round, big tubers**
MSGG426-2[c]	607	657	92	7	92	0	1	1.073	1.5	0	20	0	0	0.5	0.3	1.0	2.5	blocky round oval, medium netted, slight points,
MSDD249-09[ab]	590	612	96	3	96	0	1	1.078	1.3	0	3	0	0	1.2	0.0	1.0	2.7	blocky round oval, slight skinning, medium netted, sheep nose
NY174[b]	587	688	85	13	85	0	2	1.083	1.5	0	0	0	0	0.5	0.0	2.0	3.5	blocky tubers
Snowden[abc]	**570**	**649**	**88**	**11**	**88**	**0**	**1**	**1.075**	**1.3**	**0**	**3**	**7**	**3**	**0.5**	**0.1**	**1.5**	**2.8**	**round blocky, moderate skinning, traces of points, misshapes**
ND13220C-3[abc]	537	801	66	31	66	0	3	1.086	1.5	0	7	0	0	1.2	0.0	1.7	3.5	heat sprouts, not uniform tuber shape, misshapes, moderateerate skinning
AF6200-7[abc]	526	572	92	7	92	0	1	1.087	1.3	0	0	0	0	0.3	0.0	1.3	2.7	tuber rots, flat round oval, moderate skinning, minor growth cracks
MSGG276-4[a]	515	561	92	7	92	0	1	1.073	1.5	0	0	0	0	2.0	0.0	1.0	2.5	round oval, typy tubers
NY177[bc]	505	688	72	28	72	0	0	1.090	1.2	0	7	10	0	1.0	0.0	1.5	3.0	flat pear shaped, medium netted, moderate skinning, misshapes
MSDD247-11[abc]	501	561	88	8	88	0	3	1.078	1.2	0	3	7	3	0.5	0.0	1.3	2.2	light skin appearance, few points, variable tuber shape
B3403-6[abc]	499	602	82	17	82	0	1	1.086	1.5	3	0	7	0	1.3	0.0	1.3	2.8	moderate skinning, nice appearance, uniform tubers, points
Petoskey[b]	489	562	87	12	87	0	1	1.092	1.5	0	0	0	0	1.0	0.0	1.0	3.0	uniform tuber type
MSDD247-07[abc]	485	549	88	9	88	0	3	1.090	1.3	0	3	13	3	1.0	0.0	1.3	2.7	variable tubers size, medium netted, some points, traces of skinning
MSEE035-4[abc]	476	547	86	10	86	0	4	1.079	1.5	17	0	10	0	1.7	0.0	1.0	3.5	severe skinning, flat round oval blocky, misshapes, points
MSGG409-3[abc]	472	577	82	17	82	0	1	1.072	1.2	0	0	3	0	0.3	0.0	1.2	3.3	moderate to severe skinning, misshapes, some points, sheep nose
Mackinaw[ab]	472	529	89	10	89	0	1	1.080	1.3	0	0	5	0	0.5	0.0	1.0	3.3	uniform tuber shape, sheep nose
MSBB617-02[abc]	431	476	91	8	91	0	1	1.074	1.5	10	7	7	3	0.7	0.0	1.0	2.7	small uniform round tubers, moderate skinning, heavy netted, stem end, points
MSAA076-6[abc]	427	538	72	25	72	0	4	1.080	1.5	0	3	27	0	1.0	0.1	1.5	2.8	dark uniform tubers, flat round oval, traces of sticky stolons. Severe heat necrosis, non uniform
AF6565-8[a]	415	493	84	12	83	1	5	1.077	1.5	5	0	0	0	1.3	0.0	1.8	3.0	light skinappearance, uniform tubers, some stem end, points
Bliss[abc]	406	498	80	16	80	0	4	1.074	1.5	0	7	0	0	0.8	0.1	1.2	2.7	blocky round oval, not uniform, misshapes, typical purplish bud end, stem end, points
MSBB058-1[b]	404	503	80	20	80	0	0	1.083	1.5	0	0	20	0	0.5	0.0	1.5	4.0	small round tubers
CMK2009-630-001[abc]	400	579	67	29	67	0	4	1.076	1.5	10	13	0	0	2.0	0.0	1.5	3.0	variable tuber shape, moderate skinning, medium netted, knobs, mishapen
MSDD244-05[a]	390	461	85	12	82	3	3	1.074	1.5	0	0	20	0	1.0	0.0	1.0	2.5	sheep nose, some points, greening
AF6671-10[abc]	372	432	86	14	86	0	1	1.072	1.2	7	0	7	0	0.5	0.1	1.2	3.0	traces of rots, moderate skinning, large tubers, light skin appearance
MSEE031-3[abc]	327	411	76	19	76	0	5	1.072	1.3	0	17	10	0	0.5	0.2	1.5	3.0	dark skin uniform tubers, flat round oval, misshapes, Points, some growth cracks
Atlantic[abc]	**308**	**380**	**80**	**17**	**80**	**0**	**2**	**1.077**	**1.7**	**13**	**7**	**17**	**3**	**1.0**	**0.1**	**1.5**	**2.5**	**not uniform tuber type, very long size profile, shiny appearance**
MUI2014-011-023[abc]	285	515	54	41	54	0	6	1.079	1.8	0	23	3	0	1.5	0.2	1.8	3.0	misshapes, small size, oval oblong. Some blistered chips, golden skin
MEAN	**492**	**582**	**84**	**15**	**83**	**0**	**2**	**1.079**	**1.4**	**2**	**6**	**6**	**1**	**1.0**	**0.1**	**1.3**	**2.9**	

2025 Chip Variety Trial Sites
Black Gold[a]
Lennard Ag[b]
Walther Farms[c]

[1]**SIZE**
Bs: < 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts
% of total: Values rounded to the nearest whole number

[2]**SPECIFIC GRAVITY**
Total solids

[3]**OUT OF THE FIELD CHIP COLOR SCORE 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 2: Statewide Storage Chip Processing Trials: Summary Across Seven Locations, MI, 2025

LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	OTF CHIP SCORE[3]	RAW TUBER QUALITY[4] (%)				COMMON SCAB RATING[5]	SED SCORE[6]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
	US#1	TOTAL	US#1	Bs	As	OV	PO			HH	VD	IBS	BC					
MSGG276-4[g]	589	638	93	8	92	1	0	1.073	1.5	23	0	0	1	0.0	0.6	2.7	2.7	medium heavy netted, blocky oval
MSGG409-3[abcdeg]	557	622	89	9	87	2	2	1.079	1.3	7	16	7	2	0.9	0.3	2.0	3.1	blocky round, heavy netted, slight skinning
MSGG409-2[abceg]	518	576	88	10	84	4	2	1.079	1.4	22	7	25	0	1.3	0.2	1.7	3.0	medium netted, blocky round oval
AF6671-10[g]	503	544	92	7	92	0	1	1.082	1.5	3	16	0	0	0.3	0.7	2.6	2.3	small round size, growth cracks, medium netted
W17AF6670-1[f]	503	583	86	13	86	0	0	1.080	1.0	0	17	3	3	2.0	0.0	1.5	3.0	flat round oval, medium netted
ND13220C-3[abcdfg]	484	672	70	25	69	1	6	1.091	1.0	14	18	0	3	1.5	0.2	2.5	3.3	not uniform tuber type, light netted, not uniform size, points, mishapen
NY174[abcdefg]	478	535	88	10	88	0	1	1.086	1.2	1	13	1	0	1.3	0.4	2.1	2.8	flat blocky, round oval, medium netted, misshapen pickouts, slight skinning, nice general appearance
Petoskey[deg]	476	587	80	7	80	0	13	1.079	1.5	7	18	7	13	0.9	0.2	1.9	2.2	not uniform size, medium netted, misshaped, growth cracks, sligtht skinning, alligator hide
MSEE035-4[abcdeg]	470	525	89	8	88	1	3	1.085	1.3	8	0	16	0	1.0	0.4	1.7	3.2	light netted, flat round tuber type, growth cracks, not uniform tuber type, sticky stolons
MSHH018-3[abcdef]	451	504	88	10	85	4	2	1.077	1.3	5	4	5	0	0.9	0.2	1.7	2.4	blocky round oval, light to medium netted, sticky stolons, skinning
MSBB058-1[abcdefg]	449	492	91	8	90	1	1	1.090	1.3	0	3	4	0	1.0	0.2	1.9	2.5	deep apical eye, medium netted, moderate skinning, uniform oval tuber type
Snowden[abcdefg]	**438**	**492**	**87**	**12**	**86**	**2**	**1**	**1.078**	**1.2**	**16**	**21**	**6**	**7**	**1.5**	**0.2**	**1.9**	**2.5**	**medium netted, round oval, medium skinning, blocky round, uniform tuber type**
NY177[abcdefg]	431	526	81	16	81	0	2	1.091	1.2	0	21	7	0	1.5	0.2	1.9	2.9	flat round to oval, light netted, mocerate skinning, traces of pear shapes, growth cracks
W17066-34[f]	424	508	83	16	83	0	1	1.079	1.0	0	20	0	0	1.0	0.1	1.5	3.0	round oval, med netted, trace of growth cracks
Paige[eg]	422	555	73	26	73	0	1	1.088	1.5	2	17	0	0	1.7	0.5	2.3	3.3	flat round oval, medium netted, moderate skinning, growth cracks, not uniform tuber type
MSDD249-09[abcdeg]	415	444	93	4	90	4	3	1.081	1.3	3	12	2	0	1.3	0.3	1.7	2.6	flat blocky, growth cracks, medium netted, not uniform tuber type
MSGG426-2[bg]	414	447	93	7	92	1	1	1.078	1.5	0	20	0	0	1.0	0.6	2.5	2.1	large blocky round, heavy netted, lots of growth cracks
MSFF037-17[abeg]	408	468	87	11	87	0	2	1.079	1.4	3	16	18	0	1.7	0.1	1.8	2.6	flat round oblong, sticky stolongs, misshapen, light netted, growth cracks
AF5933-4[bg]	406	467	83	17	83	0	0	1.080	1.3	5	45	0	5	2.2	0.4	2.9	1.4	small uniform round, light netted, blocky
Mackinaw[acdeg]	398	467	85	12	84	0	3	1.088	1.3	0	23	10	0	0.9	0.1	2.0	3.0	Round oval blocky, medium netted, medium skinning, sticky stolons, ok general appearance

2025 Chip Variety Trial Sites
4-L Farm[a]
MRC Box Bin[b]
Hampton Farms[c]
Lennard Ag[d]
Main Farms[e]
Sandyland Farms[f]
Walther Farms[g]

[1]SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts
% of total: Values rounded to the nearest whole number

[2]SPECIFIC GRAVITY
Total solids

[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
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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)

LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	OTF CHIP SCORE[3]	RAW TUBER QUALITY[4] (%)				COMMON SCAB RATING[5]	SED SCORE[6]	VINE VIGOR[7]	VINE MATURITY[8]	COMMENTS
	US#1	TOTAL	US#1	Bs	As	OV	PO			HH	VD	IBS	BC					
AF6200-7[abcdefg]	397	439	90	7	89	1	4	1.088	1.4	7	6	2	0	1.0	0.5	1.7	2.4	medium netted, flat round oval blocky, points, growth cracks, medium netted
MSFF038-3[abcdeg]	392	473	83	15	81	1	2	1.079	1.3	10	3	11	0	1.3	0.3	2.3	2.5	beautiful round tuber type, medium netted, growth cracks, misshappen pick outs, slight hide skin
AF6206-5[fg]	389	460	84	12	84	0	4	1.086	1.2	0	19	0	0	2.2	0.4	2.3	2.3	blocky tuber not uniform tuber type, poor general appearance, medium netted, skinning
MSDD247-07[abcdeg]	377	418	89	9	88	1	3	1.092	1.2	2	10	32	0	0.9	0.2	1.9	2.4	blocky round, medium netted, mishapen pickouts, trace of growth cracks, slight skinning
MSDD247-11[abcdeg]	365	413	88	10	88	0	2	1.084	1.2	2	11	1	1	0.6	0.2	2.0	2.2	not uniform tuber type, medium netted, deep eyes, poor yield
MSGC20-16[b]	362	415	87	8	87	0	5	1.080	1.0	0	0	10	0	1.0	0.1	4.0	1.5	growth cracks, misshapen pickouts, round blocky tuber type, heavy netted
AF6671-10[abcde]	350	400	86	12	86	0	2	1.082	1.2	2	22	0	0	0.9	0.2	1.7	2.3	small flat round, light netted, not uniform tuber type, skinning
AF6565-8[bcdefg]	349	411	83	15	83	0	2	1.079	1.3	1	8	1	0	1.3	0.2	1.6	2.9	small round size, medium netted,growth cracks, misshapen pick outs
MSAA076-6[bdeg]	349	410	83	14	83	0	3	1.083	1.2	0	21	28	6	1.1	0.2	2.5	2.4	medium netted, pear shaped, medium netted, oval pear shape, sticky stolons
MSGB02-02[b]	348	397	88	11	88	0	1	1.084	1.0	20	0	0	0	1.5	0.1	2.5	2.0	small to medium tuber type, medium netted, growth cracks, heat sprouts
Bliss[abcdeg]	347	411	82	14	82	1	4	1.079	1.3	0	22	1	2	1.0	0.3	1.7	2.5	small round, uniform tuber type, light netted, trace of purple on apical end, growth cracks, knobby
MSEE031-3[abcdeg]	346	402	84	13	84	0	2	1.076	1.3	3	22	15	0	0.8	0.5	2.4	2.5	misshapen, growth cracks, skin cracks, skinning, pear shape, deep apical eye
MSGA24-02[b]	328	374	88	8	88	0	4	1.084	1.0	0	20	0	0	1.0	0.4	3.5	3.5	flat round tuber type, light to medium netted, uniform general appearance, growth cracks
Manistee[cde]	**297**	**359**	**82**	**17**	**82**	**0**	**0**	**1.073**	**1.3**	**0**	**13**	**13**	**0**	**1.8**	**0.4**	**1.7**	**2.5**	**misshapen, non uniform tuber type, points, knoby, medium netted**
Lamoka[abcdef]	**290**	**349**	**82**	**12**	**81**	**1**	**6**	**1.076**	**1.2**	**2**	**26**	**7**	**0**	**1.5**	**0.2**	**1.9**	**2.3**	**flat oval tuber type, medium light netted skin, trace pear shapes, pear shaped**
Kal 91.3[b]	284	346	82	16	82	0	2	1.078	1.0	30	0	0	0	1.5	0.3	3.0	2.0	light medium netted, not uniform tuber type
MSBB617-02[abcdeg]	270	301	89	7	88	1	4	1.074	1.3	15	22	5	2	0.5	0.3	1.7	2.4	blocky round, medium size tuber type, light netted, skinning
CMK2009-630-001[abcdeg]	269	430	57	37	57	0	6	1.078	1.3	10	15	0	2	2.0	0.2	2.6	2.1	smaller oval to oblong, medium netted, not uniform, points, heat sprouts
Elevate[b]	201	255	79	21	79	0	0	1.072	1.0	10	90	0	0	2.5	0.2	3.5	1.5	light medium netted, not uniform tuber type
B3403-6[b]	192	228	84	11	84	0	5	1.088	1.0	0	10	0	0	2.0	0.2	2.5	2.5	light medium netted, not uniform tuber type
MUI2014-011-023[acdeg]	187	409	43	43	43	0	13	1.080	1.1	6	11	11	0	1.5	0.3	2.2	2.4	heavy netted, not uniform tuber type, poor general appearance, round to oval
MEAN	**388**	**457**	**84**	**13**	**83**	**1**	**3**	**1.081**	**1.2**	**6**	**16**	**6**	**1**	**1.3**	**0.3**	**2.2**	**2.5**	

2025 Chip Variety Trial Sites
4-L Farm[a]
MRC Box Bin[b]
Hampton Farms[c]
Lennard Ag[d]
Main Farms[e]
Sandyland Farms[f]
Walther Farms[g]

[1]SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts
% of total: Values rounded to the nearest whole number

[2]SPECIFIC GRAVITY
Total solids

[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. Statewide Tablestock (Non-Russet) Variety Trials: Summary Across Seven Locations, MI, 2025

SKIN COLOR	LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	RAW TUBER QUALITY[4] (%)				COMMON SCAB RATING[5]	VINE VIGOR[7]	VINE MATURITY[8]	YELLOW FLESH		RED SKIN				COMMENTS
		US#1	TOTAL	US#1	Bs	As	OV	PO		HH	VD	IBS	BC				WAXINESS[7]	FLESH COLOR[8]	WAXINESS[7]	SKIN COLOR[9]	UNIFORMITY[10]	SILVER SCURF[11]	
Yellow	MSGG039-11Y[abcdefg]	516	598	63	26	63	0	11	1.070	0	3	0	0	1.2	1.7	3.7	3.5	3.2					small round oval, fairly uniform tuber type, trace of pink eye and growth cracks
	Colomba[abcdefg]	**458**	**557**	**66**	**24**	**65**	**1**	**10**	**1.056**	**7**	**26**	**12**	**0**	**0.5**	**2.5**	**2.5**	**3.0**	**3.6**					**severe heat sprouts, round oval, uniform tuber type, knoby, growth cracks**
	Saphia[abcdef]	457	691	73	16	73	0	11	1.067	0	10	0	0	1.0	1.0	3.0	2.8	4.2					bottlenecking, oblong to long, light netted, misshappen pick outs, points, growth cracks
	MSHH224-1Y[abcdefg]	450	571	83	12	82	2	5	1.065	4	9	0	6	1.1	2.5	2.9	2.8	3.0					large round uniform tuber type, trace of misshappen, trace heat sprouts
	Jelly[abcdefg]	422	513	73	24	73	0	3	1.063	0	0	0	0	0.5	3.2	3.0	3.0	4.2					knobby, points,blocky, sticky stolons, misshapen pick outs, medium netted
	Chas[abcdefg]	397	523	60	26	60	0	13	1.087	30	0	0	0	1.2	1.3	4.2	2.8	2.7					growth cracks, knobs, not uniform tuber type, misshappen, light netted
	Alaska Gold[abcdefg]	386	555	75	14	75	0	11	1.056	7	25	0	0	0.9	2.2	2.5	2.8	2.8					points, growth cracks ,sticky stolons, points, misshapen
	MUI2015-004-003[abcdef]	385	526	89	9	85	4	2	1.050	0	20	0	0	0.7	1.0	2.7	2.5	2.5					round oval blocky, medium netted
	Stella Gold[abcdefg]	379	470	50	33	49	1	16	1.064	0	15	5	1	1.1	2.7	2.7	3.1	2.6					uniform round tuber type, traces of heat sprouts, nice general appearance, some points
	Mikado[abcdef]	340	448	72	18	72	0	10	1.067	18	17	2	0	1.5	2.3	2.6	3.2	2.9					flat oblong to long, points, growth gracks, bottle necking
	Isabelia[aef]	317	432	70	27	70	0	3	1.058	1	13	10	0	0.7	2.4	2.4	3.0	2.7					not uniform tuber type, medium netted
	Gala[abcdefg]	315	442	84	9	82	2	7	1.051	0	15	0	0	0.7	3.0	2.5	3.4	3.0					severe heat sprout, uniform round oval tuber, points, light skin
	Acoustic[abcdef]	314	423	70	22	69	1	9	1.063	2	13	3	1	1.0	2.4	2.8	3.0	3.1					misshappen pick out, round oval, non unifrom tuber type, trace of rots, knobs
	W15240-2Y[abe]	298	398	60	31	59	0	10	1.063	0	7	3	3	1.2	2.5	2.7	2.7	3.1					round oval, trace of pear shapes, not uniform, bright general appearance
	Queen Anne[abcdefg]	**297**	**476**	**39**	**48**	**38**	**0**	**13**	**1.069**	**1**	**18**	**0**	**0**	**0.6**	**2.0**	**3.2**	**3.6**	**4.1**					**severe heat sprout, points, uniform elongated tubers, growth cracks**
	Samoa[acf]	297	409	65	30	64	1	5	1.075	1	5	8	0	0.9	2.6	3.0	3.0	2.8					large blocky, light skin, misshappen, growth cracks, not uniform tuber type, pineconning
	Rock[abcdefg]	278	425	63	30	63	0	7	1.056	0	6	0	0	1.4	2.3	2.9	3.4	3.8					not uniform tuber type, poor general appearance, light skin, trace of misshappen pick outs, sticky stolons
	Christel[abcdefg]	276	419	76	14	74	2	10	1.049	0	20	0	1	0.5	2.5	3.0	3.1	2.2					flat round oval, medium netted, sticky stolons
	MSII320-04Y[b]	271	304	80	14	78	1	7	1.061	0	11	1	0	1.1	2.7	2.6	3.0	3.0					oblong to long, misshapen pickouts, growth cracks, light netted
	Sound[abcdefg]	266	552	65	16	65	0	18	1.061	0	7	3	1	0.9	2.2	3.0	2.9	2.4					misshapen, flat elongated, poor appearance, not uniform tuber type, knobs
	Jola[aef]	253	398	82	9	80	2	9	1.068	0	12	0	0	0.9	2.1	3.6	2.7	3.5					misshappen pick outs, blocky oblong tuber type, trace of growth cracks, not uniform tuber type
	IPB8343-2W/Y[abe]	239	347	70	24	69	1	6	1.061	0	12	0	1	0.6	2.9	2.1	3.1	3.9					round blocky, deep eyes, sheep nose, deformed tuber type
	Tessa[abcdefg]	223	367	62	38	62	0	0	1.057	0	0	20	0	0.5	1.0	2.5	2.5	1.0					very oblong to long, tubular, not uniform tuber type, misshapen, elongated
	Arthus[aef]	179	272	68	14	68	0	17	1.071	1	11	15	3	1.4	2.7	3.2	2.8	2.8					poor tuber type, medium netted, misshappen pick out, prominent lenticels
	Odett[abcdefg]	174	430	73	26	73	0	1	1.058	0	20	2	3	1.5	2.6	2.2	3.2	3.3					not uniform skin color and tuber type, points, heat sprouts, round oval light skin
	T11[b]	105	169	81	15	80	1	4	1.062	0	12	0	0	0.6	2.5	3.1	3.1	3.6					
	MEAN	**319**	**451**	**74**	**22**	**74**	**0**	**3**	**1.060**	**0**	**7**	**11**	**0**	**0.8**	**2.1**	**2.7**	**2.7**	**2.7**					
White	**Reba[acefg]**	**488**	**512**	**95**	**4**	**94**	**1**	**1**	**1.066**	**6**	**10**	**0**	**4**	**0.6**	**3.0**	**2.8**	**2.3**	**1.0**					**blocky oval, light netted, sheep nose, uniform tuber type, deep apical eye**
	08 6840.1[abcefg]	480	605	80	9	79	1	11	1.063	3	18	2	3	1.0	2.7	3.5	2.6	1.1					blocky flat round oval, bright general appearance, not uniform, misshappen pick outs
	MSFF031-6[abcefg]	466	515	89	10	86	4	1	1.062	0	12	2	0	0.6	3.0	2.7	2.1	1.0					moderate prominent lenticels, light netted, OK general appearance, deep apical eye, sheep nose
	Superior[acdf]	**321**	**405**	**80**	**9**	**80**	**0**	**11**	**1.069**	**3**	**38**	**5**	**0**	**0.3**	**2.3**	**2.0**	**1.8**	**1.0**					**misshapen, flat, poor tuber type**
	MEAN	**439**	**509**	**86**	**8**	**85**	**1**	**6**	**1.065**	**3**	**20**	**2**	**2**	**0.6**	**2.7**	**2.8**	**2.2**	**1.0**					
Red	**Spartan Red[abcdefg]**	**496**	**554**	**89**	**8**	**87**	**3**	**3**	**1.068**	**7**	**10**	**0**	**7**	**1.3**	**3.0**	**3.1**			**2.6**	**2.9**	**2.5**	**1.3**	**flat round, moderate skinning, sticky stolons, black scurf, misshapen, poor general appearance**
	MSHH161-06R[abcdef]	445	470	95	3	89	5	2	1.060	6	7	5	26	1.4	1.8	3.5			3.2	4.8	4.9	2.6	large blocky round, moderate skinning, trace of growth cracks, sticky stolons
	AC11596-1R[abcdefg]	368	453	81	18	80	1	2	1.057	0	10	0	0	0.7	2.4	2.7			3.2	3.4	3.3	1.6	uniform round oval tuber type, acceptable general appearance
	MSHH176-2R[abcdefg]	360	420	86	11	85	1	3	1.066	1	6	0	0	0.8	3.0	3.6			2.9	2.8	3.3	1.1	severe emerging heat sprouts, sticky stolons, uniform round tuber type, mild silver scurf
	MSHH164-03RY[abcdef]	313	359	87	9	85	2	4	1.071	0	7	15	7	0.4	1.6	2.9			2.7	3.4	3.7	1.5	growth cracks, misshapen, mod skinning, uniform round tuber type
	Dark Red Norland[abcdefg]	**294**	**368**	**80**	**17**	**80**	**0**	**3**	**1.060**	**4**	**14**	**0**	**0**	**0.4**	**2.7**	**1.5**			**2.9**	**2.6**	**2.5**	**2.2**	**mod skinning, flat round, misshapen pickouts,growth cracks, OK general appearance**
	BNC981-1[def]	241	298	80	17	80	0	3	1.071	0	10	0	0	0.7	3.0	3.2			2.8	3.5	3.3	1.2	round uniform tuber type, severe silver scurf, heat sprouts
	MEAN	**360**	**417**	**85**	**12**	**84**	**2**	**3**	**1.065**	**3**	**9**	**3**	**6**	**0.8**	**2.5**	**2.9**			**2.9**	**3.3**	**3.3**	**1.6**	

2025 Russet Variety Trial Sites
4-L Farms, Inc[a]
Walther Farms[b]
Horkey Brothers Farms[c]
Jenkins Potato Farm[d]
Kitchen Farms, Inc[e]
Styma Potato Farm[f]
Verbrigghe Potato Farms[g]

[1]SIZE
Non-russet tablestock
Bs: < 1 7/8"
As: 1 7/8" - 3 1/4"
OV: > 3 1/4"
PO: Pickouts
% of total: Values rounded to the nearest whole number

[2]SPECIFIC GRAVITY
Total solids

[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 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

Table 4: Statewide Tablestock Russet Variety Trials: Summary Across Nine Locations, MI, 2025

LINE	CWT/A		PERCENT OF TOTAL[1]					SP GR[2]	RAW TUBER QUALITY[3] (%)				COMMON SCAB	VINE	VINE	COMMENTS
	US#1	TOTAL	US#1	Bs	As	OV	PO		HH	VD	IBS	BC	RATING[4]	VIGOR[5]	MATURITY[6]	
MUI2015-004-003[b]	591	750	78	11	64	14	10	1.068	10	0	0	0	2.0	1.0	3.5	dark rusetting, misshapen pickouts, growth cracks, oblong tuber type
AOR15166-2[abcdefgi]	562	616	91	7	75	16	2	1.087	0	10	0	0	0.8	2.1	3.2	light russeting, oblong to long flat, good general appearance, growth cracks
T11[i]	526	684	77	22	71	6	1	1.069	0	10	0	0	1.5	2.5	2.5	medium russeting, trace of aligator skin, points, misshapen, flat oval oblong
Silverton Russet[abcdefgi]	**461**	**580**	**77**	**12**	**62**	**15**	**10**	**1.067**	**14**	**11**	**1**	**6**	**0.3**	**2.1**	**3.5**	**moderate alligator hide, misshappen, knobs, medium russetting, growth cracks**
A12327-5VR[abcdefghi]	457	616	75	10	51	24	16	1.069	14	9	3	0	0.4	2.6	3.3	dark russet, growth cracks, good genereal appearance, alligator hide, oblong, some misshapen
Reveille Russet[abcdefghi]	**442**	**583**	**75**	**9**	**56**	**18**	**17**	**1.065**	**0**	**14**	**6**	**0**	**0.2**	**1.8**	**3.1**	**light russetting, heat sprouts, not uniform**
AF5736-16[abcdefgi]	412	479	85	9	70	15	6	1.081	22	11	10	2	0.5	1.7	3.8	medium russet, blocky oblong to long, slight deep eyes
AAF15096-1[g]	411	487	84	11	75	9	4	1.085	0	10	0	0	1.0	4.0	4.0	light medium russeting, poor general appearance, misshapen pick outs
AAF10596-1[abcdefi]	409	505	80	14	68	13	6	1.080	26	13	0	1	1.4	1.9	2.5	medium to dark russeting, not uniform tuber type, oblong, points
A18077-11TE[abcdefgi]	408	537	75	12	68	8	13	1.078	8	20	3	2	0.5	2.2	2.9	light russeting, growth cracks pickouts, misshapen, blocky to oblong
AF6377-10[abcdefgi]	407	478	84	8	60	24	8	1.071	29	14	1	0	0.3	2.0	2.6	light to medium russet, flat blocky oblong,OK general appearance, some misshapes
A18476-3adg[abcdefgi]	395	540	73	16	66	7	10	1.077	4	12	0	0	0.7	1.7	3.4	dark russeting, not uniform, moderate aligator skin, misshapen, growth cracks
AF7001-5[abcdefgi]	395	500	79	15	71	8	7	1.079	16	18	0	0	0.5	1.9	2.9	growth cracks pickouts, medium russet, slight skinning, elongated, alligator hide
AF6377-12[abcdefgi]	386	449	85	8	68	18	7	1.076	36	13	1	3	0.6	1.8	2.6	medium dark russeting, nice general appearance, oblong to long, trace of growth cracks, misshappen
Vanguard[abcdefgi]	**386**	**474**	**78**	**15**	**72**	**6**	**7**	**1.059**	**0**	**6**	**0**	**0**	**0.5**	**2.1**	**2.2**	**medium russetting, oval to oblong, medium tuber size, nice tuber type but scaby**
W20059-12RUS[abcdefghi]	374	529	71	15	59	12	15	1.064	5	10	4	0	0.5	2.2	3.7	growth cracks, misshapen, med russeting, not uniform tuber type, oblong
Russet Norkotah[abcdefghi]	**370**	**506**	**71**	**17**	**54**	**17**	**12**	**1.066**	**24**	**21**	**1**	**0**	**0.8**	**2.3**	**2.9**	**knoby, medium russet, misshapen, pine coning, growth cracks, alligator hide**
W20039-15RUS[abcdefgi]	362	460	79	13	69	10	8	1.060	0	14	2	7	0.7	2.3	2.5	dark russeting, OK general appearance, misshapen pick outs, growth cracks
A13091-5[abcdefgi]	353	444	79	16	72	6	4	1.076	9	28	1	0	0.8	2.4	3.0	poor general appearance, moderate alligator skin, medium to dark russeting, elongated
A15077-9TE[abcdefgi]	347	427	75	10	57	18	17	1.076	53	10	0	0	0.5	1.9	3.6	moderate growth cracks, aligator hide, bottlenecks, not uniform, dark russeting
A18057-2TE[abcdefgi]	332	466	71	14	63	8	15	1.069	0	19	0	0	1.4	2.1	2.9	slight aligator hide, trace of rots, blocky oblong to long, medium russet, severe growth cracks, misshapen
Gold Rush[abcdeg]	**297**	**403**	**70**	**15**	**59**	**11**	**15**	**1.063**	**6**	**4**	**0**	**0**	**0.1**	**2.2**	**2.9**	**medilum russetting, oblong, small tubers, pine coning, very tubular**
A18224-2[i]	278	482	53	30	50	3	17	1.054	0	30	0	0	0.5	2.3	4.0	tubular, knoby, point, medium russeting, misshape, oblong to long
OR11222-4[i]	185	451	41	41	41	0	18	1.064	0	80	0	0	0.5	1.5	2.5	medium dark russet, flat oblong, misshappen pick outs
CO15070-4RUS[abcdefgi]	164	334	48	45	48	0	6	1.064	0	7	0	0	0.0	2.2	2.2	medium russeting, blocky oval oblong, good general appearance, not uniform tuber type
MEAN	**388**	**511**	**74**	**16**	**63**	**11**	**10**	**1.071**	**11**	**16**	**1**	**1**	**0.7**	**2.1**	**3.0**	

2025 Table Russet Variety Trial Sites
4-L Farms, Inc[a]
Elmaple Farms LLC[b]
Horkey Brothers Farms[c]
Jenkins Potato Farm[d]
Kitchen Farms, Inc[e]
Lennard Ag Co.[f]
Styma Potato Farm[g]
Verbrigghe Potato Farms[h]
Walther Farms[i]

[1]**SIZE**
Russets
Bs: < 4 oz
As: 4 - 10 oz
OV: > 10 oz
PO: Pickouts
% of total: Values are rounded to the nearest whole number

[2]**SPECIFIC GRAVITY**
Total solids

[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: 6/10/2025
Rating 1-5
1: Slow emergence
5: Early emergence (vigorous vine, some flowering)

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

Potato Storage Studies

Study 1: Effect of sprout inhibitor treatments and bin inlet airflow timing on chip quality in Bliss and Mackinaw

Introduction

Chip quality deterioration in stored processing potatoes is often linked to changes in tuber physiology that elevate sugar levels, promote sprouting, and increase internal and external defects, ultimately reducing chip quality. This study evaluated the effects of sprout inhibitors and bin inlet closure period after sprout inhibitor application on chip quality in two processing cultivars, Bliss and Mackinaw. Potatoes were piled up in storage bins and treated with 1,4-dimethylnaphthalene (1,4Sight®) and Isopropyl 3-chlorocarbanilate (Chlorpropham®) (CIPC) and 1,4Zap® in Michigan Potato Industry Commission (MPIC) storage facilities during 2024-2025 located adjacent to the Michigan State University Montcalm Research Center (MRC). Tubers were sampled biweekly and chip quality assessed.

Study a: Air inlet closure duration effects on chip quality of early-harvested Bliss potatoes treated with 1,4Sight® in bulk bin storage

Potatoes were harvested on September 30, 2024, from Sandyland Farms and piled into two storage bins (Bins 1 and 2) on the same date. Bin dimensions measured 10 ft × 12 ft × 20 ft, and the bin load weighed about 570 cwt. Pulp temperature at loading were 63.5 °F for both bins. A 0.03 fl oz cwt^{-1} dose of 1,4Sight was applied to both bins on October 1, 2024. Following 1,4Sight® application, Bin 1 air inlet was closed for 12 hours before ventilation was initiated on October 2, while Bin 2 air inlet remained closed for 48 hours before fan activation on October 3. A 0.1 oz cwt^{-1} dose of CIPC® and 0.03 fl oz cwt^{-1} of 1,4Zap® were applied to both bins on October 29, 2024. The average storage pulp temperatures were 52°F (Bin 1) and 51°F (Bin 2). Tubers were unloaded on February 24, 2025. During storage period, a sample of 40 tubers were collected biweekly and submitted to Techmark Inc. for assessment of glucose, sucrose, SFA color, and chip defects (external, internal, and greening).

Results

Air inlet closure duration had no significant effect on any trait. Days in storage significantly affected the sucrose content but not the other quality parameters (Table 1). Sucrose levels peaked early in storage, with the highest at 35 days (0.91 (%×10)) and 21 days (0.86 (%×10)), then gradually declined to the lowest at 147 days (0.48 (%×10)) (Table 2). The SFA color score was comparable across treatments, while internal defects and undesirable chips were minimal and not subjected to further analysis (data not shown).

Study 1: *p*-values for chip quality traits of early harvested Bliss treated with 1,4Sight®, under air inlet closure duration prior to fan activation in MPIC storage bins, MRC, 2024–2025.

Sources of variation	Glucose content	Sucrose content	External defects	Greening effects	Total defects
Air inlet closure duration	0.9694	0.1828	0.0986	0.6408	0.1623
Days in storage	0.2026	0.0172	0.2421	0.3105	0.4437

Table 2: Mean sucrose content of early harvested Bliss treated with 1,4Sight®, under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Days in storage	Sucrose content (%×10)
0	0.6812 abc
21	0.8590 ab
35	0.9071 a
49	0.6096 abc
65	0.5796 abc
77	0.6739 abc
98	0.6590 abc
119	0.4982 bc
133	0.5912 abc
147	0.4770 c

Study b: Air inlet closure duration effects on chip quality of early-harvested Bliss potatoes treated with 1,4Sight® in bulk bin storage

The crop was harvested on October 08, 2024, from Sandyland Farms and piled into two storage bins (bins 3 & 4) on the same date. Bin dimensions measured 10 ft × 12 ft × 20 ft, and the bin load weighed about 570 cwt. The temperature at loading was 62 °F for both bins. A 0.03 fl oz cwt^{-1} dose of 1,4Sight® was applied to both bins on October 13, 2024. After 1,4Sight® application, Bin 3 was closed for 12 hours while Bin 4 was closed for 24 hours before initiating bin ventilation. A 0.1 oz cwt^{-1} dose of CIPC® and 0.03 fl oz cwt^{-1} of 1,4Zap® were applied to both bins on November 11, 2024. The average storage pulp temperature for both bins was 50°F. Tubers were unloaded on March 24, 2025. During storage, a sample of 40 tubers were collected biweekly and submitted to Techmark Inc. for analysis of glucose, sucrose, SFA color, and chip defects (external, internal, and greening).

Results

Air inlet closure duration had a significant effect only on sucrose content (Table 3). Bin 3 (12 h closure) had 0.034 %×10 higher sucrose content than Bin 4 (24 h closure) (Table 4). Days in storage significantly affected glucose, sucrose, and total defects (Table 3). Storage time significantly affected glucose and total defects overall, but no single time point differed significantly after multiple comparison adjustments, indicating gradual changes over time (Table 5 and 6). Sucrose content declined by half from day 0 to 166, with a significant decrease after day 40 (Table 5). The SFA color score was comparable across treatments, while internal defects, greening, and undesirable chips were minimal and not subjected to further analysis (data not shown).

Table 3: *p*-values for chip quality traits in late harvested Bliss treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025.

Sources of variation	Glucose content	Sucrose content	Total defects
Air inlet closure duration	0.1098	0.0180	0.2509
Days in storage	0.0105	<.0001	0.0172

Table 4: Mean sucrose content over time in late harvested Bliss treated with 1,4Sight® under bin closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Bin	Sucrose content (%×10)
3 (12 h air inlet closure)	0.4623 a
4 (24 h air inlet closure)	0.4283 b

Table 5. Mean glucose and sucrose content of late harvested Bliss treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Bin	Glucose content	Sucrose content
	%	%×10
0	0.0025 a	0.7255 a
12	0.0020 a	0.6055 ab
26	0.0025 a	0.6006 ab
40	0.0020 a	0.4743 cb
56	0.0010 a	0.3937 cd
68	0.0010 a	0.4056 cd
89	0.0010 a	0.4182 cd
110	0.0015 a	0.3656 cd
124	0.0010 a	0.4007 cd
138	0.0010 a	0.3258 d
152	0.0000 a	0.4299 cd
166	0.0011 a	0.3508 d

Table 6: Mean total defects over time in late harvested Bliss treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Days in storage	Total defects (%)
0	3.7360 a
12	8.1460 a
26	17.580 a
40	11.950 a
56	5.8410 a
68	16.790 a
89	0.0000 a
110	4.5790 a
124	3.3840 a
138	6.7520 a
152	5.2550 a
166	5.7780 a

Study c: Air inlet closure duration effects on chip quality of Mackinaw potatoes treated with 1,4Sight® in bulk bin storage

Potatoes were harvested on October 08, 2024, from Sandyland Farms and piled into two storage bins (bins 5 & 6) on the same date. Bin dimensions measured 10 ft × 12 ft × 20 ft, and the bin load weighed about 570 cwt. The pulp temperatures at loading were 58 ºF (Bin 5), and 57 ºF (Bin 6). A 0.03 fl oz cwt^{-1} dose of 1,4Sight®formulation was applied to both bins on October 13, 2024. Following 1,4Sight® application, Bin 5 was closed for 12 hours and Bin 6 for 48 hours before fan activation for air inlet. A 0.1 oz cwt^{-1} dose of CIPC® and 0.03 fl oz cwt^{-1} of 1,4Zap® were applied to both bins on November 14, 2024. The average pulp temperatures during storage were 50 °F (Bin 5) and 49°F (Bin 6). Potatoes were unloaded on March 24, 2025. During storage, tuber samples were collected biweekly and taken to Techmark Inc. for chip quality assessment on glucose, sucrose, SFA color, and chip defects (external, internal, and greening).

Results

Days in storage significantly affected glucose, sucrose, external and total defects, while air inlet closure duration effects were not significant except for total defects (Table 7). Glucose content peaked at 0.006% (12-26 days), declined to 0.001% (124-208 days), slightly rose at 222 days, and overall decreased with storage time (Table 8). Sucrose peaked at 1 %×10 (26 days), then dropped to 0.5 %×10 (138 days), showing an overall decline during storage (Table 8). Bin 5 (24 h closure) had 5% more mean total defects than Bin 6 (48 h closure) (Table 9). External defects fluctuated, peaking at 26% (68 days) and reaching a minimum of 1% (138 days). Total defects remained consistently high, with peaks near 27% (236 days) and occasional declines at 40, 124, and 166 days (Table 10). The SFA color score was comparable across treatments, while internal defects, greening, and undesirable chips were minimal and not subjected to analysis (data not shown).

Table 7: *p*-values for chip quality traits in Mackinaw treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025.

Sources of variation	Glucose content	Sucrose content	External defects	Total defects
Air inlet closure duration	0.6630	0.2352	0.1663	0.0474
Days in storage	0.0008	0.0006	0.0047	0.0019

Table 8: Mean glucose content over time in Mackinaw treated with 1,4Sight® under bin closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Days in storage	Glucose content	Sucrose content
	%	%×10
0	0.0041 ab	0.9650 abc
12	0.0056 a	1.0447 ab
26	0.0056 a	1.1091 a
40	0.0041 ab	1.0096 abc
56	0.0026 ab	0.8285 abcd
68	0.0026 ab	0.9940 abc
89	0.0021 ab	0.8146 abcd
110	0.0015 ab	0.7376 abcd
124	0.0011 b	0.6750 bcd
138	0.0018 ab	0.5398 d
152	0.0011 b	0.7637 abcd
166	0.0016 ab	0.6728 bcd
187	0.0011 b	0.5850 dc
208	0.0011 b	0.7100 abcd
222	0.0031 a	0.9828 abcd
236	0.0021 ab	0.7982 abcd

Table 9: Mean total defects in Mackinaw treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across days in storage.

Bin	Mean total defects (%)
Bin 5 (24 h air inlet closure)	14.860 a
Bin 6 (48 h air inlet closure)	11.450 b

Table 10: Mean external and total defects over time in Mackinaw treated with 1,4Sight® under air inlet closure durations prior to fan activation in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Days in storage	External defects	Total defects
	%	
0	1.822 abc	9.944 a
12	14.160 abc	13.460 a
26	22.430 ab	23.050 a
40	6.833 abc	6.012 b
56	21.020 ab	20.450 a
68	25.770 a	26.920 a
89	11.720 abc	10.970 a
110	20.040 ab	21.450 a
124	7.722 abc	6.916 b
138	1.037 c	3.266 a
152	14.600 abc	13.900 a
166	6.372 abc	5.550 b
187	1.418 bc	22.920 a
208	8.698 abc	7.904 a
222	17.840 abc	22.340 a
236	25.200 a	27.000 a

Study d: Effects of 1,4Sight® on Mackinaw potatoes in bulk bin long-term storage

Potatoes were harvested on September 20, 2024, from Main Farms and piled into two storage bins (Bins 8 & 9) on the same date. Bin dimensions measured 10 ft × 12 ft × 20 ft, and the bin load weighed about 625 cwt. A 0.03 fl oz cwt^{-1} dose of 1,4Sight® formulation was applied to bin 8 on September 24, 2024, and air inlet was closed for 24 hours before ventilation was initiated. Bin 9 was the untreated control, receiving no 1,4Sight® application, with continuous air inlet operation under conventional management. On October 24, 2024, both bins were treated with 0.1 oz cwt^{-1} CIPC® and 0.03 fl oz cwt^{-1} 1,4Zap®. The average pulp temperature during storage was 50 °F in both bins. Tubers were unloaded on June 2, 2025. During storage, tuber samples were collected biweekly and shipped to Techmark Inc. for chip quality assessment on glucose, sucrose, SFA color, and chip defects (external, internal, and greening).

Results

Bin effects were non-significant for all traits. Storage duration significantly affected sucrose and total defects (Table 11). Sucrose content rose to a peak of 1.4 %×10 at 46 days, then generally declined (Table 12, Fig. 1). Total defects fluctuated, peaking at 28% by 88 days (Table 12, Fig. 2). Overall, sucrose showed a rise followed by a decline, and total defects varied without a clear trend.

Table 11: *p*-values for chip quality traits in Mackinaw treated 1,4Sight® in MPIC storage bins, MRC, 2024-2025.

Sources of Variation	Glucose content	Sucrose content	External defects	Total defects
Bin	0.1094	0.0714	0.4533	0.1557
Days in storage	0.5293	0.0044	0.6892	0.0059

Table 12: Mean sucrose content and total defects over time in Mackinaw treated with 1,4Sight® in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Days in storage	Sucrose content	Total defects
	%×10	%
0	0.8833 abc	7.359 ab
11	1.0292 abc	15.68 ab
32	1.1673 abc	4.496 b
46	1.3671 a	15.270 ab
60	1.1896 abc	14.340 ab
76	1.1779 abc	8.763 ab
88	1.2428 ab	27.680 a
109	1.1245 abc	13.480 ab
130	1.0898 abc	12.780 ab
144	0.7946 abc	15.000 ab
158	0.7946 bc	11.810 ab
172	0.9884 abc	9.380 ab
186	0.8891 abc	4.781 b
207	0.7684 c	10.480 ab
228	0.8146 bc	3.109 b
242	0.9587 abc	8.788 b
252	1.0370 abc	18.390 ab

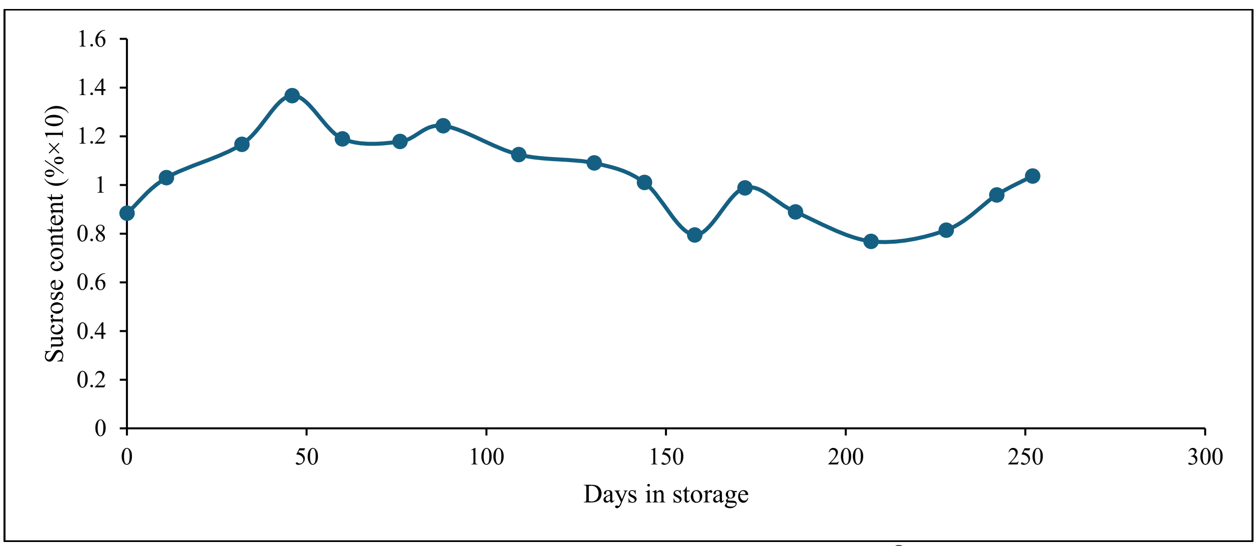

Fig. 1. Mean sucrose content over time in Mackinaw treated 1,4Sight® in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

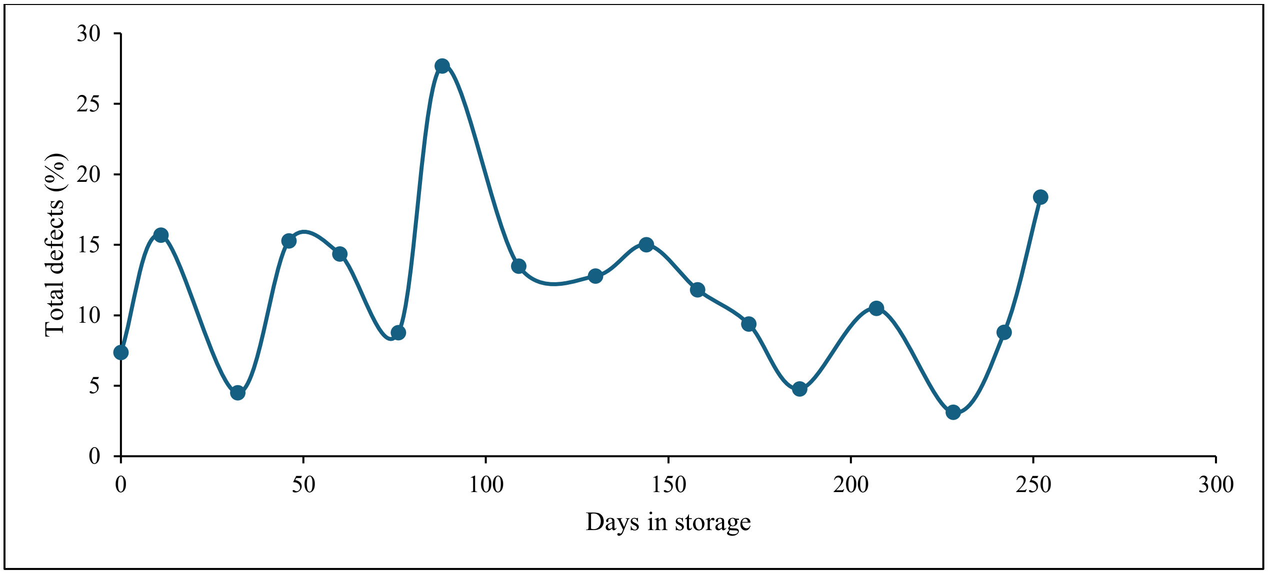

Fig. 2. Mean total defects over time in Mackinaw treated with 1,4Sight® in MPIC storage bins, MRC, 2024-2025, data pooled across bins.

Findings

For Bins 1 through 6, duration of storage demonstrated a stronger and more consistent influence on chip quality traits, significantly affecting sucrose content and, in some cases, glucose content and total defects.

In contrast, air inlet closure duration prior to fan activation generally showed minimal influence, with isolated effects on external defects and sucrose content. However, longer air inlet closure reduced mean total defects in Mackinaw, indicating a limited, trait-specific influence.

For Bins 8 and 9, 1,4Sight® treatment did not enhance the long-term storage performance of Mackinaw potatoes for chip processing compared to the non-treated control, but duration of storage affected sucrose content and total defects.

Study 2: Chip quality evaluation of advanced potato breeding lines in long-term box bin storage

Objective: To assess the chip-processing quality of potato lines from public and private breeding programs following long-term box bin storage.

Materials and methods

Field trials

Forty-five entries were evaluated with Snowden as a check (Table 13). Seed potatoes (120 cwt) were planted in single 34-inch rows with 10-inch seed spacing on May 10, 2024, at the Michigan State University Montcalm Research Center, Entrican, MI. Crops were vine-killed on September 3 and harvested on September 24, 2024. A 23-foot section of the row was harvested for yield evaluation, while the remaining portion was harvested for postharvest storage studies. Preharvest and yield data are provided in the 2024 farmer packet (https://www.canr.msu.edu/potatooutreach).

Storage trials

The study was conducted from September 23, 2024, to June 2, 2025, evaluating 45 potato entries (Table 13). For each entry, 10 cwt of tubers were placed in a ventilated plastic box bin, stacked in Bulk Bin 7 to ensure airflow via forklift openings and a plenum recirculation system. On October 24, 2024, the bin (Bin 7) was treated with CIPC® (0.1 oz cwt^{-1}) and 1,4Zap® (0.03 fl oz cwt^{-1}). The average pulp temperature was 55 ºF during storage. Box bins were equipped with access doors for biweekly sampling.

An initial out of field sample was collected directly from the field on September 23, 2024, immediately after harvest and prior to binning, followed by a biweekly sampling of 40 tubers per entry for chip quality analysis at Techmark Inc. Entries with unacceptable chip quality were discontinued from subsequent sampling.

Chip quality was evaluated using a rank summation method. Entries were scored across key traits including chip color, glucose, sucrose, and total defects, all measured as percentages. Rankings were based on both mean performance and maximum values, representing the worst case during the storage period. Ranks for each trait were summed to generate a total rank score, with lower scores indicating superior performance.

Results

Chip color and individual defects (internal, external, and greening) were similar across most entries (data not shown). Therefore, the ranking was primarily based on glucose and sucrose content, and total defects. Summary of results is presented in Table 13.

×10

Table 13: Glucose and sucrose content, total defects, and rank summaries of 45 potato breeding lines in box bins stacked in Bin 7 at MPIC, MRC, MI (Sept 23, 2024 – June 2, 2025).

Line	Mean glucose (%)	Rank (mean glucose)	Maximum glucose (%)	Rank (maximum glucose)	Mean sucrose (%×10)	Rank (mean sucrose)	Maximum sucrose (%×10)	Rank (maximum sucrose)	Mean total defects (%)	Rank (mean defects)	Maximum total defects (%)	Rank (maximum defects)	[1]Total rank score (summation)	[2]N
MSBB058-1	0.0014	15	0.0029	21	0.5436	6	0.7789	6	2.69	3	5.63	7	58	16
MSDD244-15	0.0011	5	0.0021	11	0.5724	7	0.8182	9	3.76	12	10.24	19	63	15
MSEE016-10	0.0016	18	0.0019	7	0.7494	26	0.8504	10	0.66	1	2.72	1	63	9
Bliss (Late Sandyland)	0.0012	8	0.0026	17	0.3996	1	0.5606	2	9.15	30	12.25	24	82	11
MSDD249-9	0.0012	9	0.0021	10	0.6308	9	1.0438	26	4.96	15	9.71	16	85	16
MSBB230-1	0.0008	1	0.0014	1	0.7363	23	0.9261	16	6.65	24	12.25	23	88	4
MSBB060-1	0.0022	30	0.0027	20	0.7286	21	0.8714	13	2.07	2	4.35	3	89	9
Elevate	0.0010	3	0.0014	2	0.6480	13	0.7809	7	11.51	40	15.10	29	94	9
MSDD247-07	0.0008	2	0.0019	8	0.8891	36	1.3806	37	3.12	6	4.90	6	95	16
MSEE031-3	0.0014	13	0.0022	13	0.7472	25	0.8562	11	5.05	16	11.43	21	99	10
NY177	0.0011	7	0.0018	4	0.7515	27	1.0196	24	7.51	27	9.24	14	103	16
MSBB630-2	0.0015	17	0.0021	12	0.5015	3	0.6247	3	10.88	39	15.48	30	104	4
MSGG302-1	0.0014	14	0.0018	5	0.7544	28	0.9043	15	7.02	25	9.84	17	104	5
Bliss_BB	0.0013	10	0.0046	26	0.5841	8	0.9955	21	4.30	13	14.68	27	105	16
MSDD372-07 (Low N)	0.0013	10	0.0026	18	0.9461	38	1.1618	32	3.14	7	4.32	2	107	8
NY174	0.0011	6	0.0023	14	0.6599	14	0.7701	5	12.42	41	19.89	33	113	16
MSDD247-11	0.0017	20	0.0027	19	0.8653	35	1.0885	28	3.66	11	4.71	4	117	16
AF6671-10	0.0019	24	0.0048	27	0.6672	16	1.0365	25	5.63	17	7.41	9	118	16
MSDD244-05	0.0017	21	0.0056	31	0.6380	11	1.2288	34	2.76	4	10.29	20	121	14
MSGA24-02	0.0010	4	0.0019	6	1.0563	42	2.8263	44	3.47	10	9.30	15	121	16
MSFF029-10	0.0017	19	0.0018	3	0.8378	32	0.9540	17	7.18	26	14.20	26	123	9
Dundee	0.0018	22	0.0033	24	0.8644	34	1.4626	38	3.34	9	4.88	5	132	16
Kal.91.03	0.00144	15	0.0024	16	1.4711	45	4.0466	45	3.06	5	7.36	8	134	16
Mackinaw (Main Farms)	0.0013	12	0.0023	15	0.9196	37	1.3435	35	6.51	23	8.87	13	135	15
Bliss (Early Sandyland)	0.0021	26	0.0032	23	0.5016	4	0.9820	20	9.19	32	18.71	32	137	11
CMK2009-630-001	0.0022	29	0.0052	29	0.7407	24	1.1341	30	4.92	14	8.25	12	138	15
AC13126-1Wadg	0.0039	40	0.0154	44	0.5326	5	0.7017	4	6.01	20	16.76	31	144	13
MSAA076-6	0.0039	41	0.0114	42	0.6475	12	1.1895	33	3.25	8	8.22	11	147	13
AF5933-4	0.0027	34	0.0057	32	0.7346	22	1.0191	23	6.18	21	10.24	18	150	16
MSBB630-2 (Low N)	0.0030	36	0.0030	22	0.4770	2	0.4770	1	63.70	45	63.70	45	151	1
MSFF037-17	0.0023	31	0.0086	37	0.7771	29	1.1214	29	5.64	18	8.19	10	154	16
MSBB230-1 (Low N)	0.0020	25	0.0020	9	0.7870	30	0.7870	8	59.00	44	59.00	44	160	1
NYU34-6	0.0018	22	0.0049	28	0.6894	18	1.5393	39	7.52	28	12.84	25	160	16
Snowden	**0.0031**	**37**	**0.0090**	**38**	**0.6616**	**15**	**0.8977**	**14**	**10.70**	**38**	**15.06**	**28**	**170**	**11**
MSEE035-4	0.0027	35	0.0059	33	0.7193	19	0.9554	18	10.27	35	20.55	35	175	15
AC13125-5W	0.0045	43	0.0103	41	0.6349	10	0.8647	12	9.81	34	27.72	40	180	13
Mackinaw (Sandyland)	0.0024	32	0.0052	30	0.7283	20	1.0734	27	10.40	37	20.19	34	180	15
B3403-6	0.0031	38	0.0038	25	0.9524	39	1.3579	36	9.54	33	12.24	22	193	8
MSFF038-3	0.0035	39	0.0137	43	0.6677	17	1.0041	22	9.15	31	38.41	41	193	13
ND13220C-3	0.0025	33	0.0083	36	1.0198	41	1.8531	40	5.79	19	22.77	36	205	13
MSDD376-4 (Low N)	0.0021	27	0.0065	34	1.2613	43	2.3715	43	8.78	29	27.06	39	215	8
AF6896-1	0.0091	45	0.0098	39	0.8239	31	0.9817	19	33.91	43	44.50	42	219	7
MSDD376-4	0.0021	28	0.0080	35	0.9897	40	2.0065	41	10.28	36	50.24	43	223	15
MSGG409-3	0.0039	42	0.0103	40	0.8615	33	1.1527	31	15.11	42	23.63	38	226	16
Sinatra	0.0056	44	0.0219	45	1.2896	44	2.1568	42	6.18	22	23.25	37	234	8

[1]Lower values indicate better performance (ranking assigns lowest rank to ties).

[2]Number of times sampled

Study 3: Evaluation of pressure bruise susceptibility in advanced potato breeding lines after long-term storage at varying pile heights

Pressure bruising, characterized by sunken discoloration and tuber weight loss, poses a major challenge in chip potato storage due to its effect on quality and marketability. This study evaluated the effects of pile height on pressure bruise incidence, internal discoloration, and weight loss in advanced potato breeding lines during the 2024-2025 storage season at the MRC, MI. Tubers were stored at pile heights of 3, 8, and 14 ft in MPIC bins (10 ft × 12 ft × 20 ft), loaded with 570 cwt (Bins 1-6) or 625 cwt (Bins 8 and 9). Each breeding line (20 lbs. per replicate, three replicates per pile height) was placed during bin loading; lines were not replicated across bins. Breeding lines, pile heights, bin loading and unloading dates are presented in Table 14. Bins were unloaded on different dates based on the quality retention of the piled variety.

Tuber weight was recorded at loading, while weight loss, pressure bruise incidence, and internal discoloration of bruised tubers were assessed at unloading. Mean separations for effects of breeding line, pile height, and their interaction on weight loss, pressure bruise incidence, and internal discoloration are presented in Tables 15-35.

Table 14: Storage bins, pressure bruise test lines, and loading and unloading dates at MRC, Michigan, 2024-2025.

Bin	Load variety	Pressure bruise test lines	Loading date	Unloading date
1	Bliss (Sandyland early)	Bliss (Sandyland early), Elevate, Kal.91-03, MSDD247-07, MSGA24-02	9.30.2024	2.24.2025
2	Bliss (Sandyland early)	Bliss (Sandyland early), MSBB058-1, MSDD249-9, MSEE016-10, MSFF038-3	9.30.2024	2.24.2025
3	Bliss (Sandyland late)	Bliss (MRC), Bliss (Sandyland late), MSDD247-11, MSDD376-4, NY177	10.08.2024	3.24.2025
4	Bliss (Sandyland late)	Bliss (Sandyland late), CMK2009-630-1, MSAA076-6, ND13220C-3, NYU34-6	10.08.2024	3.24.2025
5	Mackinaw (Sandyland)	MSDD244-05, MSGG409-3, Mackinaw (Sandyland), NY174, Snowden	10.08.2024	6.02.2025
6	Mackinaw (Sandyland)	MSDD244-05, MSGG409-3, Mackinaw (Sandyland), NY174, Snowden	10.08.2024	6.02.2025
8	Mackinaw (Main Farms)	Mackinaw	9.20.2024	5.29.2025
9	Mackinaw (Main Farms)	Mackinaw	9.20.2024	5.29.2025

Table 15: Mean weight loss, pressure bruise incidence, and bruise without discoloration for five potato entries at three pile heights in MPIC Bulk Bin 1 at MRC, MI, 2024. Data averaged across pile heights.

Entry	Weight loss	Tubers with bruise	Tubers with bruise and no color
		%	
Bliss (Sandyland early)	4.45 c	93.54 a	63.59 a
Elevate	7.27 a	0.01 c	0.01 c
Kal.91-03	4.43 c	0.01 c	0.01 c
MSDD247-07	5.32 b	5.11 b	2.04 b
MSGA24-02	4.85 cb	18.51 b	9.17 b
p value	<.0001	<.0001	<.0001

Table 16: Mean weight loss, pressure bruise incidence, and bruise without discoloration for potatoes stored at different pile heights in MPIC Bulk Bin 1 at MRC, MI, 2024. Data averaged across entries.

Pile height	Weight loss	Tubers with bruise	Tubers with bruise and no color
ft		%	
3	5.63 a	2.79 a	0.645 a
8	4.79 ab	1.68 a	1.189 a
14	5.16 b	1.13 a	0.698 a
p value	0.0019	0.4588	0.6671

Table 17: Mean number of tubers without pressure bruise for five potato entries at three pile heights in MPIC Bulk Bin 1 at MRC, MI, 2024.

Entry	Pile height	Mean tuber number without pressure bruise
	ft	%
Bliss (Sandyland early)	3	0 c
Bliss (Sandyland early)	8	25 bc
Bliss (Sandyland early)	14	51 b
Elevate	3	100 a
Elevate	8	100 a
Elevate	14	100 a
Kal.91.03	3	100 a
Kal.91.03	8	100 a
Kal.91.03	14	100 a
MSDD247-07	3	94 b
MSDD247-07	8	82 b
MSDD247-07	14	99 ab
MSGA24-02	3	97 ab
MSGA24-02	8	82 b
MSGA24-02	14	84 b
p value		0.0168

Table 18: Mean weight loss of five potato entries in MPIC Bulk Bin 2 at MRC, MI, 2024, averaged across three pile heights.

Entry	Weight loss
	%
Bliss (Sandyland early)	3.88 ab
MSBB058-1	3.13 b
MSDD249-9	5.40 a
MSEE016-10	2.88 b
MSFF038-3	3.48 b
p value	0.0004

Table 19: Mean number of tubers without pressure bruise and bruise without discoloration for five potato entries at three pile heights in MPIC Bulk Bin 2 at MRC, MI, 2024.

Entry	Pile height	Tuber number without bruise	Tubers with bruise and without discoloration
	ft	%	
Bliss (Sandyland early)	3	2.11 c	63.27 a
Bliss (Sandyland early)	8	37.17 b	32.30 a
Bliss (Sandyland early)	14	58.24 b	36.73 a
MSBB058-1	3	53.05 b	42.09 a
MSBB058-1	8	63.96 b	35.94 a
MSBB058-1	14	75.15 b	24.67 a
MSDD249-9	3	48.18 b	50.00 a
MSDD249-9	8	75.24 b	23.60 ab
MSDD249-9	14	97.89 a	1.99 c
MSEE016-10	3	51.82 b	42.03 a
MSEE016-10	8	49.46 b	49.29 a
MSEE016-10	14	97.89 a	2.450 bc
MSFF038-3	3	51.82 b	48.17 a
MSFF038-3	8	65.69 b	34.19 a
MSFF038-3	14	54.52 b	36.09 a
p value		<.0001	0.0007

Table 20: Mean weight loss of five potato entries in MPIC Bulk Bin 3 averaged across three pile heights, MRC, MI, 2024.

Entry	Weight loss
	%
Bliss (MRC)	3.40 b
Bliss (Sandyland late)	4.01 ab
MSDD247-11	5.15 a
MSDD376-4	5.15 a
NY177	3.66 b
p value	<.0001

Table 21: Mean weight loss for potatoes stored at three pile heights in MPIC Bulk Bin 3 at MRC, MI, 2024. Data averaged across entries.

Pile height	Weight loss
ft	%
3	4.23 ab
8	4.63 a
14	3.82 b
p value	0.0452

Table 22: Mean number of tubers without pressure bruise and bruise without discoloration for five potato entries at three pile heights in MPIC Bulk Bin 3 at MRC, MI, 2024.

Entry	Pile height	Tuber number without bruise	Tubers with bruise and without discoloration
	ft		%
Bliss (MRC)	3	3.524 g	63.51 abcd
Bliss (MRC)	8	28.16 bcdef	51.95 bcde
Bliss (MRC)	14	63.73 ab	31.98 ef
Bliss (Sandyland late)	3	10.87 egf	84.64 a
Bliss (Sandyland late)	8	23.96 cdefg	68.68 abc
Bliss (Sandyland late)	14	63.07 abc	35.19 def
MSDD247-11	3	4.538 gf	78.68 ab
MSDD247-11	8	35.48 bcde	59.71 abcde
MSDD247-11	14	78.23 a	20.84 f
MSDD376-4	3	34.16 bcde	55.86 bcde
MSDD376-4	8	46.82 abcd	50.64 bcde
MSDD376-4	14	49.40 abcd	49.33 cdef
NY177	3	22.96 defg	70.50 abc
NY177	8	41.94 abcde	54.55 bcde
NY177	14	64.02 ab	32.41 ef
p value		0.0019	0.0038

Table 23: Mean weight loss of five potato entries in MPIC Bulk Bin 4 across three pile heights, MRC, MI, 2024.

Entry	Pile height	Weight loss	Tuber number without bruise
	ft		%
Bliss (Sandyland late)	3	4.81 abcde	12.96 de
Bliss (Sandyland late)	8	3.38 f	20.57 de
Bliss (Sandyland late)	14	3.58 def	49.77 bcd
CMK2009-630-1	3	3.57 ef	36.54 cde
CMK2009-630-1	8	3.79 cdef	52.42 abcd
CMK2009-630-1	14	3.88 cdef	80.80 abc
MSAA076-6	3	5.25 ab	5.981 e
MSAA076-6	8	5.38 ab	44.07 cde
MSAA076-6	14	4.87 abcd	78.67 abc
ND13220C-3	3	4.65 abcde	92.73 ab
ND13220C-3	8	4.14 bcdef	93.53 a
ND13220C-3	14	4.94 abc	86.01 abc
NYU34-6	3	5.40 ab	38.12 cde
NYU34-6	8	5.70 a	47.07 cde
NYU34-6	14	5.89 a	47.82 cd
p value		0.0066	0.0107

Table 24: Mean tubers with bruise and without discoloration of five potato entries in MPIC Bulk Bin 4 averaged across three pile heights, MRC, MI, 2024.

Entry	Tubers with bruise and without discoloration
	%
Bliss (Sandyland late)	66.63 a
CMK2009-630-1	40.24 b
MSAA076-6	40.27 b
ND13220C-3	4.95 c
NYU34-6	42.37 b
p value	<.0001

Table 25: Mean tubers with bruise and without discoloration for potatoes stored at three pile heights in MPIC Bulk Bin 4 at MRC, MI, 2024. Data averaged across entries.

Pile height	Tubers with bruise and without discoloration
ft	%
3	47.64 a
8	36.72 a
14	20.14 b
p value	0.0002

Table 26: Mean weight loss of five potato entries in MPIC Bulk Bin 5 across three pile heights, MRC, MI, 2024.

Entry	Weight loss
	%
MSDD244-05	6.80 b
MSGG409-3	5.34 c
Mackinaw (Sandyland)	5.59 c
NY174	7.02 ab
Snowden	7.72 a
p value	<.0001

Table 27: Mean weight loss for potatoes stored at three pile heights in MPIC Bulk Bin 5 at MRC, MI, 2024. Data averaged across entries.

Pile height	Weight loss
ft	%
3	6.67 a
8	6.03 b
14	6.62 a
p value	0.0111

Table 28: Mean number of tubers without pressure bruise for five potato entries at three pile heights in MPIC Bulk Bin 5 at MRC, MI, 2024.

Variety	Pile height	Tuber number without bruise
	ft	%
MSDD244-05	3	1.453 def
MSDD244-05	8	11.40 bc
MSDD244-05	14	26.70 ab
MSGG409-3	3	6.06 cde
MSGG409-3	8	6.06 cde
MSGG409-3	14	28.03 ab
Mackinaw (Sandyland)	3	11.89 bc
Mackinaw (Sandyland)	8	16.75 bc
Mackinaw (Sandyland)	14	45.40 a
NY174	3	0.45 f
NY174	8	0.71 ef
NY174	14	45.44 a
Snowden	3	14.07 bc
Snowden	8	10.39 bcd
Snowden	14	45.19 a
p value		<.0001

Table 29: Mean tubers with bruise and without discoloration of five potato entries in MPIC Bulk Bin 6 across three pile heights, MRC, MI, 2024.

Entry	Tubers with bruise and without discoloration
	%
MSDD244-05	75.29 a
MSGG409-3	79.14 a
Mackinaw (Sandyland)	64.23 b
NY174	64.26 b
Snowden	57.54 b
p value	<.0001

Table 30: Mean tubers with bruise and without discoloration for potatoes stored at three pile heights in MPIC Bulk Bin 5 at MRC, MI, 2024. Data averaged across entries.

Pile height	tubers with bruise and without discoloration
ft	%
3	73.36 a
8	73.75 a
14	57.64 b
p value	<.0001

Table 31: Mean weight loss of five potato entries in MPIC Bulk Bin 6 across three pile heights, MRC, MI, 2024.

Entry	Weight loss
	%
AC13125-5W	9.63 a
AC13126-1wadg	5.89 bc
AF5933-4	7.89 abc
Dundee	8.02 ab
Mackinaw (Sandyland)	5.78 c
p value	<.0001

Table 32: Mean number of tubers without pressure bruise and bruise without discoloration for five potato entries at three pile heights in MPIC Bulk Bin 6 at MRC, MI, 2024.

Variety	Pile height	Tuber number without bruise	Tubers with bruise and without discoloration
	ft		%
AC13125-5W	3	1.57 e	97.99 a
AC13125-5W	8	1.57 e	69.87 b
AC13125-5W	14	13.88 abcde	64.44 cb
AC13126-1wadg	3	3.89 ed	50.70 cb
AC13126-1wadg	8	3.89 ed	45.49 cb
AC13126-1wadg	14	3.61 ed	51.87 cb
AF5933-4	3	34.19 abc	50.99 cb
AF5933-4	8	6.63 cde	62.40 cb
AF5933-4	14	45.57 ab	44.29 cb
Dundee	3	10.33 bcde	55.81 cb
Dundee	8	4.09 cde	66.18 cb
Dundee	14	21.43 abcd	55.81 cb
Mackinaw (Sandyland)	3	12.01 bcde	59.47 cb
Mackinaw (Sandyland)	8	26.58 abcd	51.87 cb
Mackinaw (Sandyland)	14	58.07 a	29.62 c
p value		0.0430	0.0034

Table 33: Mean weight loss of Mackinaw potatoes stored in MPIC Bulk Bins 8 and 9 across three pile heights, MRC, MI, 2024.

Bin	Weight loss
	%
8	4.97 b
9	5.96 a
p value	0.0134

Table 34: Mean weight loss of Mackinaw potatoes at three pile heights, averaged across MPIC Bulk Bins 8 and 9, MRC, MI, 2024.

Pile height	Weight loss
ft	%
3	6.29 a
8	5.30 ab
14	4.83 b
p value	0.0140

Table 35: Mean number of tubers without pressure bruise and bruise without discoloration for five potato entries at three pile heights in MPIC Bulk Bin 6 at MRC, MI, 2024.

Pile height	Tuber number without bruise	Tubers with bruise and without discoloration
ft	%	
3	12.39 b	52.68 a
8	16.19 b	58.94 a
14	51.33 a	44.47 a
p value	<.0001	0.1577

Assessment of variety resistance to four postharvest diseases of potato in Michigan, 2025

Mio Satoh-Cruz, Azamat Sardarbekov, Chris Long, and Jaime F. Willbur; Plant, Soil and Microbial Sciences

Cultivars with postharvest disease resistance can provide economical and effective management. However, robust phenotyping of variety responses is needed. In this study, chipping potato commercial lines and germplasm were assessed for resistance to four major postharvest diseases: Fusarium dry rot, bacterial soft rot, pink rot, and Pythium leak.

Materials and Methods

1) Postharvest disease variety screening. During 2024-25, harvested and stored tubers from nine chipping lines comprising commercial varieties and research germplasm were obtained from the MSU Potato Outreach Program box bin trial conducted at the MSU Montcalm Research Center (Montcalm County). All materials were tested at three replicate timepoints (5 tubers/timepoint/disease).

Asymptomatic tubers were rinsed with tap water and air-dried overnight at ambient conditions. For all pathogens, 10 µl of inoculum was injected to a 1 cm depth at the apical and basal ends of each tuber using a Hamilton® syringe (710 series, 100-µl volume). Tubers were inoculated with suspensions of the following: 2 x 10^4 *Fusarium sambucinum* conidia/ml in water; 2 x 10^4 *Phytophthora erythroseptica* zoospores/ml in 10% soil extract; 5 x 10^4 *Pythium ultimum* sporangia/ml in potato dextrose broth; or 8 x 10^8 *Pectobacterium carotovorum* cfu/ml in LB broth. One additional *Fusarium* species, *F. graminearum* identified during surveys of Michigan storage piles, was also used in dry rot screening. Tests for dry rot and pink rot were incubated in paper bags under ambient conditions for 28 or 6 days, respectively. Pythium leak and soft rot tests were incubated in plastic bags with moist paper towels at room temperature for 6 days. After incubation, tubers were sliced longitudinally through inoculation sites and internal symptom width and depth were measured using digital calipers. Data was analyzed using an analysis of variance (ANOVA) conducted with the generalized linear mixed model (GLIMMIX) procedure in SAS v. 9.4, and means were compared using Fisher's protected LSD (α=0.05).

2) Residual effects of dimethylnaphthalene. We assessed the residual effects of a 20 ppm dimethylnaphthalene (DMN) (1,4Sight®) post-bin loading treatment on dry rot, pink rot, Pythium leak, and soft rot development in Mackinaw tubers. Mackinaw tubers were harvested from a MSU Potato Outreach Program field location (Main Farms) on 20 Sep 2024, stored in MPIC storage facilities, and treated with and without 0.03 fl oz/cwt (20 ppm) of 1,4-dimethylnaphthalene (DMN) (1,4Sight®) on 24 Sep 2024. Treated and non-treated tuber samples were collected from both top and bottom these bins and inoculated for disease testing in three minimum replicate timepoints. Tubers were inoculated with each disease and assessed as described above.

3) Pathogenicity of Plectosphaerella in tubers. We investigated the potential pathogenicity of a *Fusarium*-like fungal organism commonly observed from tubers with dry rot symptoms in 2024 samples. This organism was morphologically and molecularly characterized as *Plectosphaerella* *cucumerina*, which has been previously found to cause stunting, root, and crown rot in pepper and tomato (Raimondo and Carlucci 2018). Eight *Plectosphaerella* isolates (LJ8 to 1B5B-1) as well as isolates of *Fusarium* sp. (Fus25), *F. oxysporum* (Oxy25), and *F. graminearum* (Gra25) from dry rot symptomatic tubers in 2025 were selected and tested for pathogenicity and virulence on Lamoka tuber slices. These were compared with known virulent *Fusarium sambucinum* (Samb) and *F. graminearum* (Gra) isolates and a potato dextrose (PDA) negative control.

Overall Summary

1) Postharvest disease variety screening. Postharvest resistance to four diseases was screened in chipping (Figure 1 and 3) potato entries using Michigan pathogen isolates. No clear relationship was observed between resistance responses to different diseases; however, as observed in 2025, Bliss and NY177 possessed at least moderate resistance to three or four diseases.

From 2025 testing, Bliss exhibited greater resistance to pink rot, Pythium leak and dry rot, Snowden also had greater resistance to dry rot and soft rot, but tended to be more susceptible to pink rot and Pythium leak, and Mackinaw exhibited susceptibility to soft rot, dry rot, and Pythium leak this year. MSBB058-1 exhibited moderate resistance to dry rot and pink rot.

While dry rot responses to *F. graminearum* and *F. sambucinum* generally followed similar trends, several varieties may have seemed more or less resistant depending on the species used, such as Bliss and MSDD247-07 (Figure 2). For example, using only the *F. sambucinum* standard isolate, Bliss dry rot susceptibility caused by *F. graminearum* may have been missed.

2) Residual effects of dimethylnaphthalene. We also assessed the effects of a 20 ppm DMN treatment on dry rot, pink rot, Pythium leak, and soft rot using Mackinaw, however there were not significant differences for most diseases (Figure 4). A slight reduction in Pythium leak symptoms was observed in treated bottom of the bin tubers ($P < 0.01$).

3) Pathogenicity of Plectosphaerella in tubers. From this preliminary assay, all *Plectosphaerella* isolates were comparable to the mock-inoculated media control and considered likely not pathogenic (Figure 5). While *Fusarium* isolates Oxy25 and Gra25 were also not significantly different from the PDA media control, minimal symptoms were formed on tuber slices though 80% less than than the virulent *F. sambucinum* and *F. graminearum* positive controls (Figure 5A). The whole tuber assay showed similar results as the slice assay, but *Plectosphaerella* isolates did cause significant though very minor infection (Figure 5B); repetitions of this assay will be conducted in the future. From these preliminary assays with Lamoka tubers, *Plectosphaerella* isolates were considered to exhibit low virulence.

Acknowledgements

We would like to thank the grower cooperators and key industry representatives who contributed to this research, our fellow researchers and undergraduate research assistants in the Michigan State University Potato and Sugar Beet Pathology and Potato Outreach programs, the Montcalm Research Center, the Michigan Potato Industry Commission, MSU AgBioResearch, and the MSU RTSF Genomics Core for their continued support of our research.

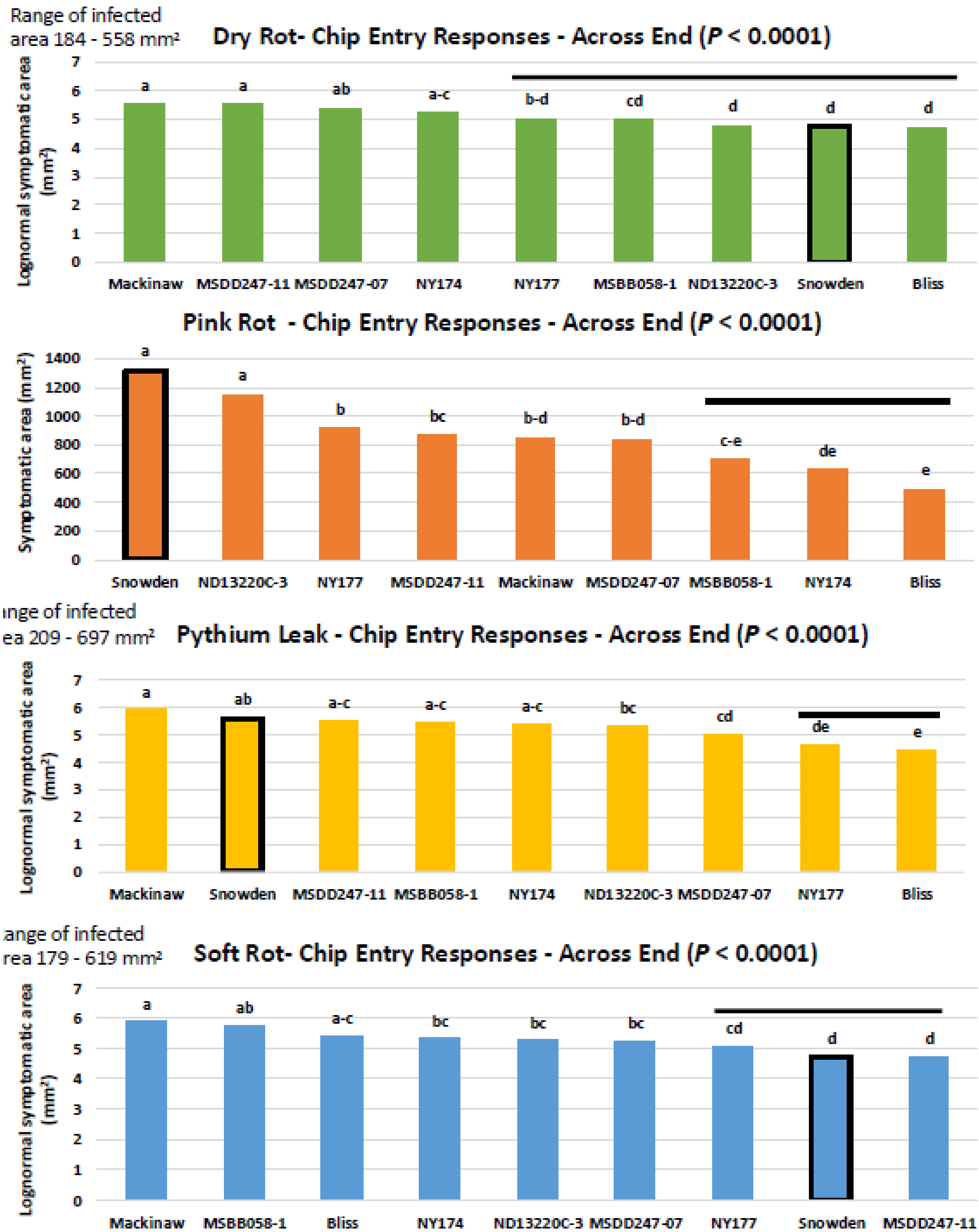

Figure 1. Responses of nine chipping potato lines to dry rot, pink rot, Pythium leak, and soft rot. Bars with the same letter not significantly different based on Fisher's protected LSD (α=0.05). Means are across apical and basal end responses ($P < 0.0001$) for dry rot, pink rot, soft rot, and Pythium leak ($P < 0.001$) in tubers from MSU Potato Outreach Program field locations (Montcalm Research Center) tested in three minimum replicate timepoints.

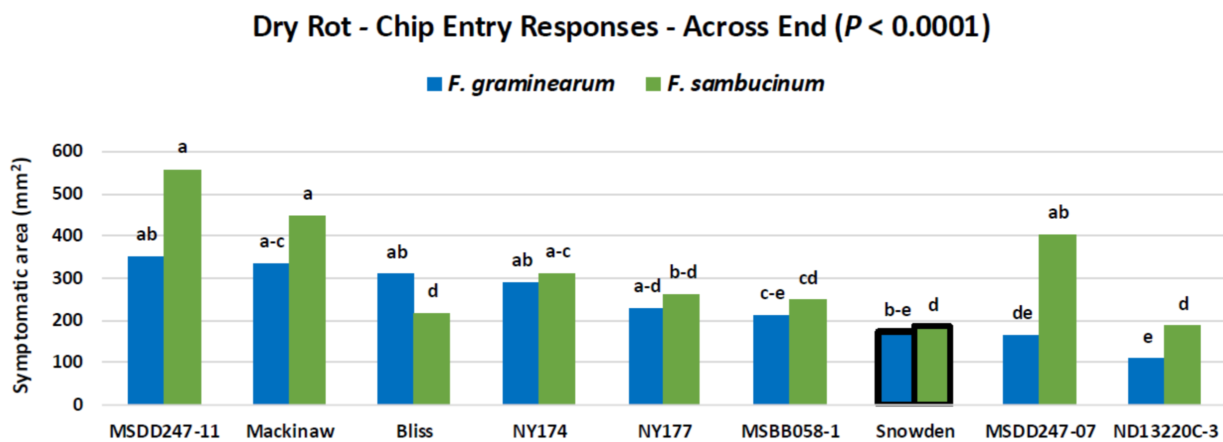

Figure 2. Responses of nine chipping potato lines to dry rot caused by two species of *Fusarium* prevalent in Michigan potato samples. *F. graminearum* (blue), *F. sambucinum* (green). Bars with the same letter not significantly different based on Fisher's protected LSD (α=0.05). Significant variable responses were observed across apical and basal ends ($P < 0.0001$).

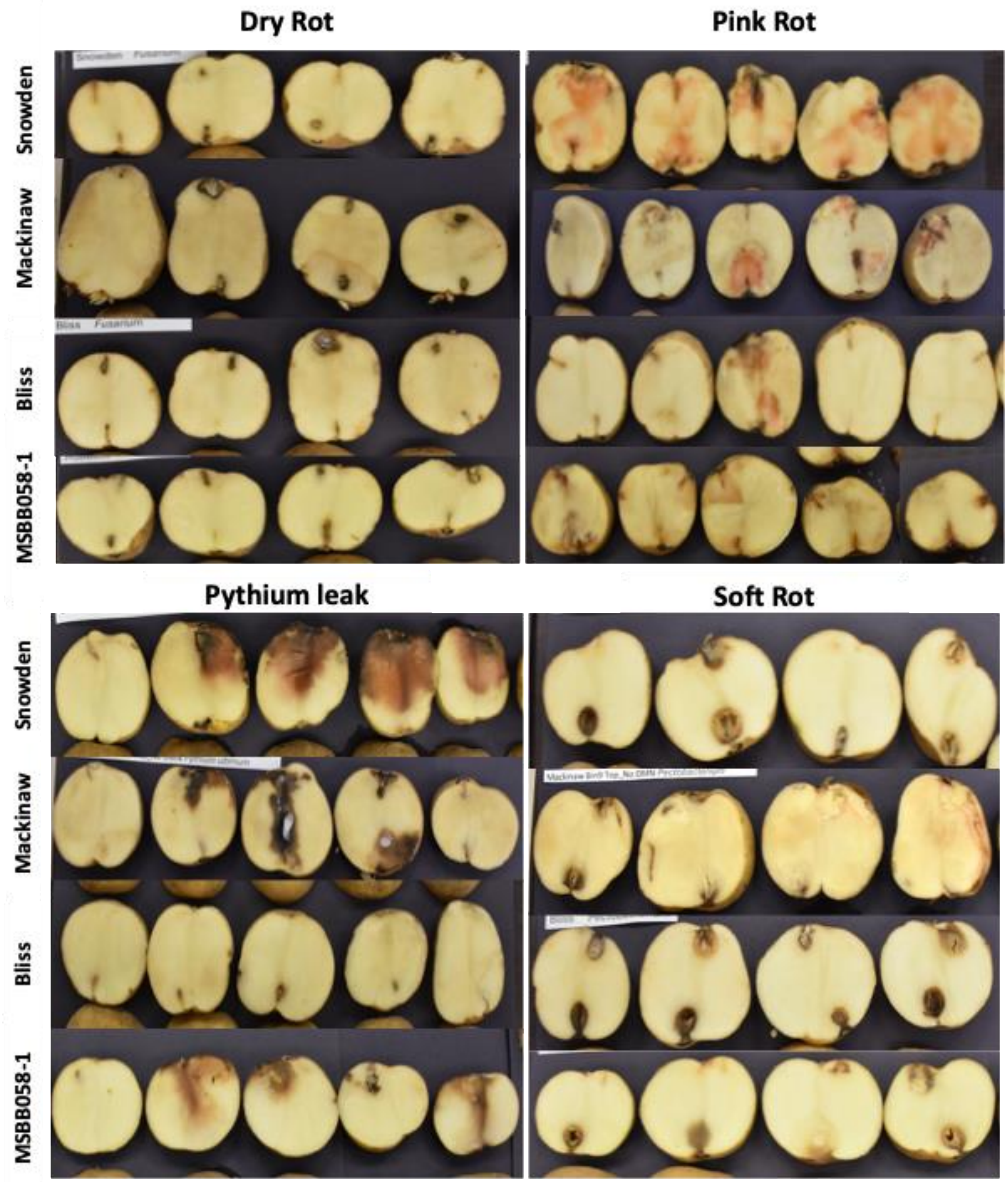

Figure 3. Examples of typical symptoms for each of the four tested postharvest diseases. Bliss had greater resistance to pink rot, Pythium leak and dry rot, Snowden also had greater resistance to dry rot and soft rot, but tended to be more susceptible to pink rot and Pythium leak, and Mackinaw exhibited susceptibility to soft rot, dry rot, and Pythium leak this year. MSBB058-1 exhibited moderate resistance to dry rot and pink rot.

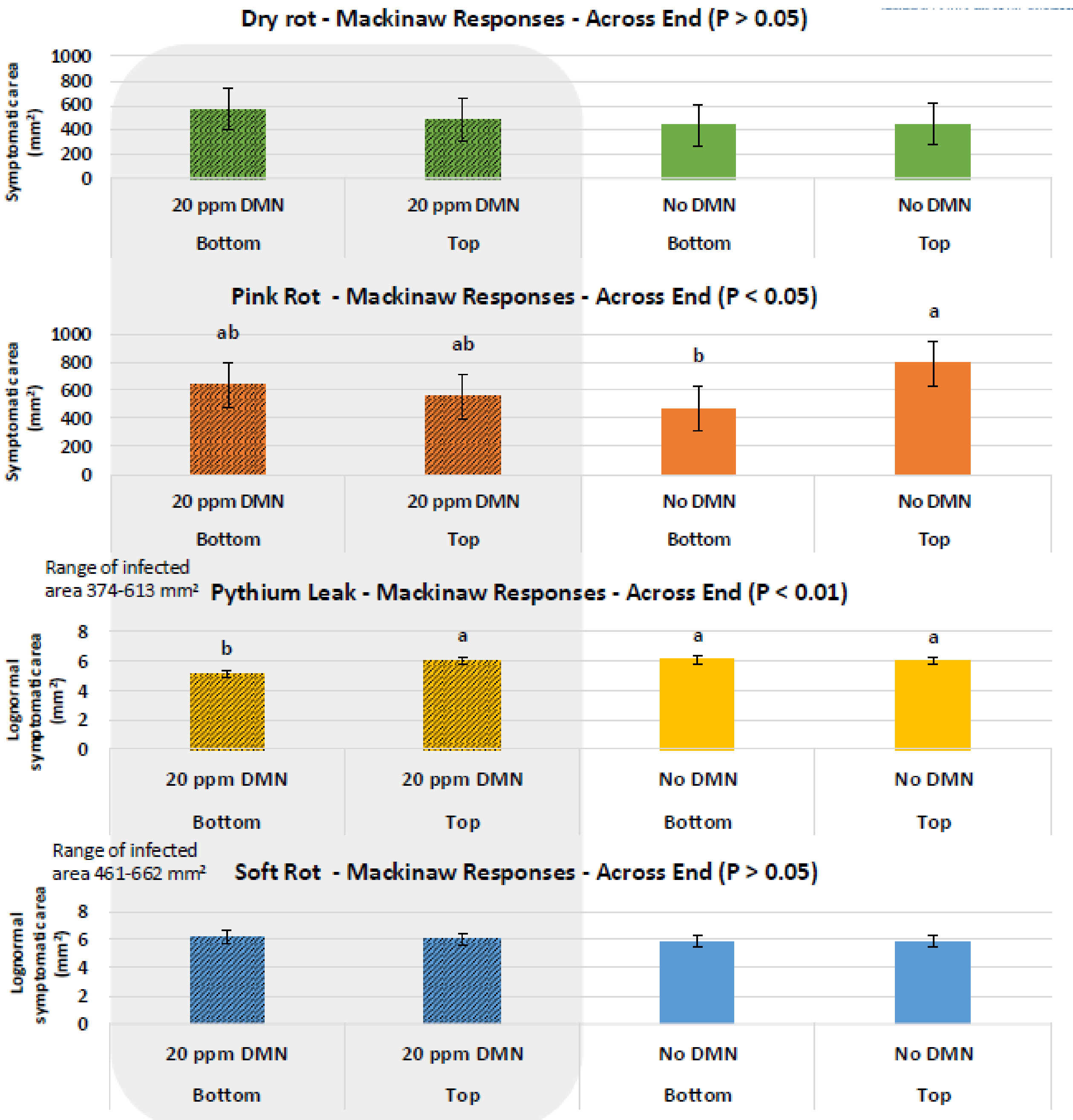

Figure 4. Effect of 20ppm DMN treantment to dry rot, pink rot, Pythium leak, and soft rot. Mackinaw were harvested from a MSU Potato Outreach Program field location (Main Farms) on 20 Sep 2024, stored in MPIC storage facilities, and treated with and without 0.03 fl oz/cwt (20 ppm) of 1,4-dimethylnaphthalene (DMN) (1,4Sight®) on 24 Sep 2024. Treated and non-treated tuber samples were collected from both top and bottom these bins and inoculated for disease testing in three minimum replicate timepoints. Bars with the same letter not significantly different based on Fisher's protected LSD (α=0.05). There were no consistent significant differences between treatment for any disease, except a slight reduction in Pythium leak symptoms observed in treated bottom of the bin tubers (P <0.01).

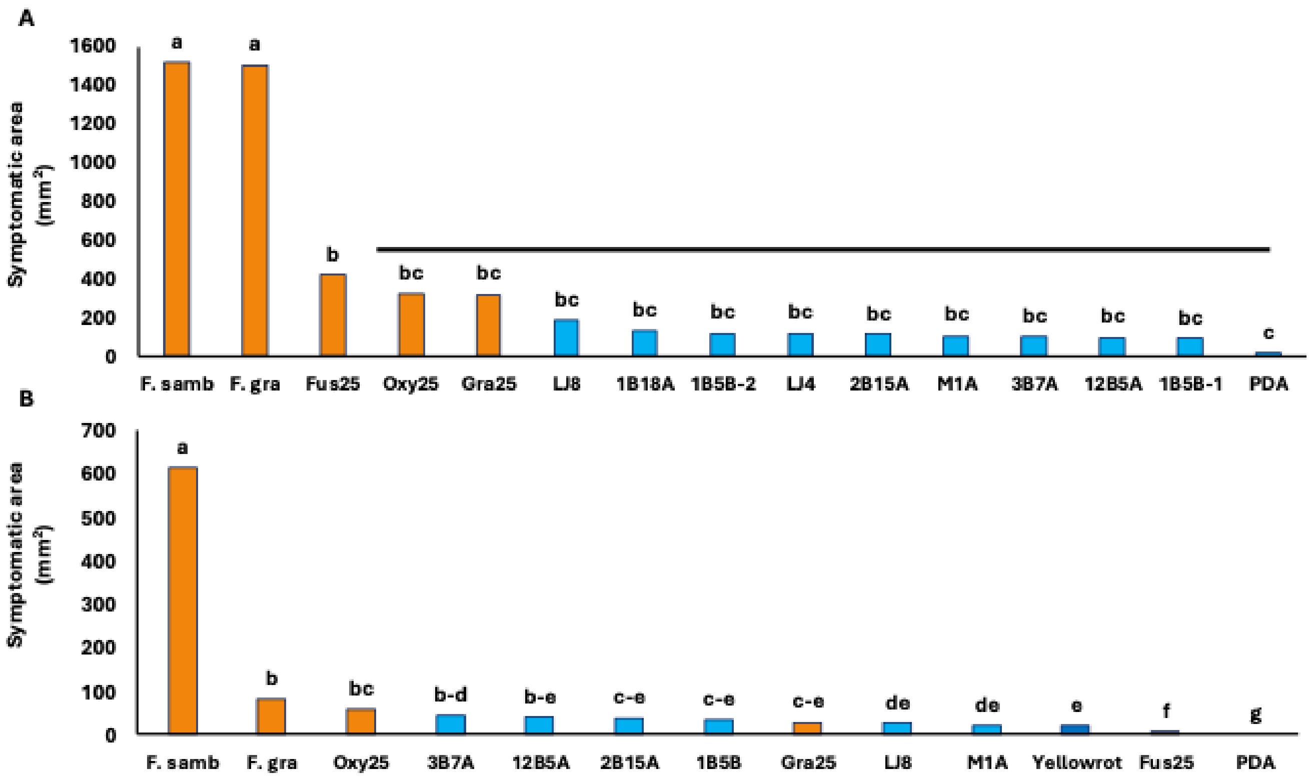

Figure 5. *Fusarium* (blue bars) and *Plectosphaerella* (orange bars) isolate virulence and pathogenicity assay conducted on A) tuber slices measured at four days post-inoculation (DPI4) ($P < 0.0001$) and B) in whole tubers measured at 28 days post-inoculation (DPI28) ($P < 0.0001$). *Plectosphaerella* sp. isolates were observed frequently in submitted dry rot samples in 2024. Eight *Plectosphaerella* isolates (LJ8 to 1B5B-1) as well as isolates of *Fusarium* sp. (Fus25), *F. oxysporum* (Oxy25), and *F. graminearum* (Gra25) from dry rot symptomatic tubers in 2025 were selected and tested for pathogenicity and virulence on Lamoka tuber slices and whole tubers. These were compared with known virulent *Fusarium sambucinum* (F. samb) and *F. graminearum* (F. gra) isolates and a potato dextrose (PDA) negative control. From these preliminary assays with Lamoka tubers, *Plectosphaerella* isolates were considered to exhibit low virulence.

Diagnostic optimization of viral detection and characterization of Potato virus Y for the Michigan seed potato certification program, 2025

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The MSU Potato and Sugar Beet Pathology (PSBP) program continues to work with the Michigan Department of Agriculture and Michigan Seed Potato Association to: 1) investigate detection options to identify accurate, timely, and cost-effective methods for use in Michigan seed potato certification, 2) monitor PVY strain and other tuber necrotic virus prevalence in Michigan seed potatoes, and 3) investigate PVY strain by chipping potato variety responses.

Materials & Methods:

In 2024, we shifted to using immunocapture-reverse transcription-polymerase chain reaction (IC-RT-PCR) (Chikh-Ali and Karasev, 2015) methods for faster and more cost-effective methods to screen for PVY in seed tubers. In 2025, IC-RT-PCR method is well adapted in Michigan. We will be continuing further research comparison for accuracy, efficiency, and cost effectiveness.

In 2025-26, an MDARD-MSPA awarded specialty crop block grant will support direct tuber testing and growout comparison in 80 seed lots from growers. In general, samples of 400 tubers were collected from each lot. Direct tuber testing with IC-RT-PCR was conducted in 10-tuber subsamples at least two weeks postharvest. Cored samples were then suberized and sent to Hawaii for planting and winter grow-out. Results from direct tuber and leaflet ELISA methods will be compared. Subsets of positive samples will be subject to PVY strain confirmation by RT-PCR (Chikh-Ali et al. 2013; Lorenzen et al. 2006, 2010; Mackenzie et al. 2015).

We also are repeating assays to assess PVY strain by variety responses (Gundersen et al. 2019). Based on Michigan survey observations, three chipping lines and varieties of interest were selected for repeat greenhouse experiments (Lamoka, NY163, and Manistee) and screened using three prevalent PVY strains (N-Wi, NTN, N:O) in a greenhouse assay. These experiments are currently in progress for 2025-26.

In 2023-24, a survey was conducted of PVY strain types from positive seed certification samples as well as of two other tuber necrotic viruses, Potato mop-top virus (PMTV) and Tobacco rattle virus (TRV) in Michigan using qPCR methods from Mumford et al. (2000).

Results & Conclusions:

- In 2024-25, PVY strain NTN was most prevalent, exceeding frequencies of strain N-Wi for the first time since our surveys began in 2019 (Figure 1A). Furthermore, 23% of samples were mixtures of NTN and N-Wi (Figure 1B).
- From two years of survey for PMTV and TRV in Michigan seed lots, only one positive sample was detected in 2023; however, positive tuber samples were asymptomatic and did not exhibit typical internal necrosis (Figure 2). This result suggests these viruses are not a major concern at this time but support continued monitoring in the future.

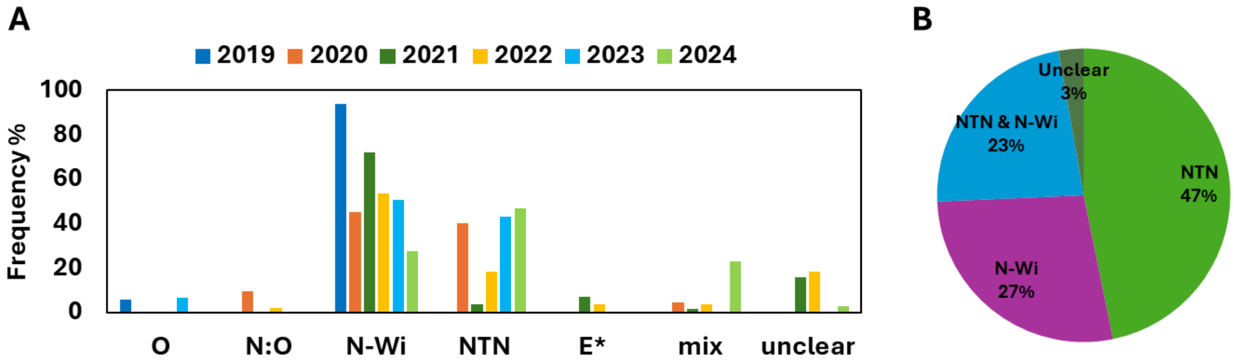

Figure 1. A) Representative PVY strains collected from Michigan potato seed certification program postharvest tests and B) breakdown of strains and strain mixtures in 2024-25. In 2020-21, N = 212 positives in 17,752 total samples. In 2021-22, N = 57 positives in 21,600 total samples. In 2022-23, N= 54 positives in 7,150 total samples. In 2023-24, N= 62 positives in 10,200 total samples. In 2024-25, N= 216 positives in 12,764 total samples. *In 2023, nine positive samples were included as N-Wi; Chikh-Ali et al. (2013) primers indicated suspect N-Wi but confirmation using Lorenzen et al. (2006) multiplex primers did not distinguish between N:O and N-Wi strains.

	2023	2024
# tubers	2,237	2,779
# lots	18	26
# positive PMTV	1	0
# positive TRV	1	0
Total % PMTV	5.6%	0%
Total % TRV	5.6%	0%

Figure 2. Survey of potato mop top virus (PMTV) and Tobacco rattle virus (TRV) in Michigan seed growing regions in 2023-2024. From 2023 and 2024, a total of 5,016 tubers representing 44 lots were screened for PMTV and TRV. In 2023, we detected one positive lot for both PMTV and TRV, however, this PMTV-positive sample was asymptomatic as shown above.

Acknowledgements:
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Evaluation of banded at re-hill and foliar fungicides to manage early blight and brown spot of potato in Michigan, 2024

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Keywords: Endura Pro, Lucento, Luna Tranquility, Scala SC, Topguard

Experimental and commercially available fungicides were tested to determine their efficacy in managing potato early blight (*Alternaria solani*) and brown spot (*Alternaria alternata*). A field trial was established at the Montcalm Research Center in Stanton, MI. Soil type at the station is loamy sand. A randomized complete block design was used with four replicates. US#1 'Lamoka' potatoes were cut into 2-oz seed piece and left to suberize before planting. The trial was planted 28 May. Plots were two rows wide (34-in row spacing) by 18 ft long and seeded at 1.2 seed/row-ft. Banded treatments were applied at re-hilling on 2 July. A CO_2-powered backpack sprayer, equipped with TJ2504 nozzles, was used to apply fungicides at 20 gal/A. Due to the trial's proximity to commercial potato fields, a blanket application of Echo 720 was applied weekly after row-closure to the entire trial to reduce the risk of late blight developing near commercially grown potatoes. Beginning at early flower, three foliar applications (B, C, and D) were made across programs. Application dates were B=15 July, C=31 July, and D=14 Aug. The previously mentioned sprayer was used to make applications, except TJ8004XR nozzles were used. Plots were inoculated 23 July and 30 July with *A. solani* solution ($8x10^3$ conidia/mL) at a volume of 20 gal/A. Foliar disease data (combined early blight and brown spot observations) were collected regularly throughout the growing season. Plots were harvested 25 September; both rows were dug and later graded. The final disease incidence (DI) and disease severity (DS) collected 18 August, estimated yield, and estimated marketable 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).

Disease pressure was moderate, and differences were observed among the foliar DI ($P< 0.0001$) but not DS ($P>0.05$). All tested programs had significantly lower incidence (15-23.3%) than the control (DI=48.8%); severity was numerically lower in all tested programs than in the control but was not significantly lower. No significant differences were observed in yield or marketable yield.

No.	Treatment (Rate[a]) Timing[b]	Disease Incidence (%)[c]		Disease Severity (%)	Total Yield (cwt/A)	Marketable Yield (cwt/A)
1	Treated control	48.8	a	15.8	348.5	313.3
2	Luna Tranquility (11.2 fl oz) B + Luna Tranquility (11.2 fl oz) C + Scala SC (7 fl oz) D	23.0	bc	15.0	307.7	276.7
3	Endura Pro (18.5 fl oz) B + Endura Pro (18.5 fl oz) C + Scala SC (7 fl oz) D	15.0	c	15.0	319.2	284.6
4	Experimental (22.8 fl oz) B + Experimental (22.8 fl oz) C + Scala SC (7 fl oz) D	16.5	bc	13.8	331.7	300.8
5	Lucento (11 fl oz) A	18.8	bc	15.0	317.2	281.4
6	Topguard (28 fl oz) A	23.3	b	14.5	329.1	293.3
7	Topguard (28 fl oz) A + Luna Tranquility (11.2 fl oz) C	20.5	bc	15.0	306.8	274.3
8	Lucento (5.5 fl oz) B + Lucento (5.5 fl oz) C + Scala SC (7 fl oz) D	17.0	bc	13.0	335.7	297.9
	SE	2.7		0.9	14.6	15.6
	P-value	<0.0001		0.4709	0.5603	0.5586
	LSD	8.0		-	-	-

[a] All rates are listed as amount of product applied per acre.

[b] Application letters code for the following dates: A=Jul 2 (at hill), B=Jul 15 (flower), C=Jul 31 (flower + 2 weeks), D=Aug 14 (flower + 4 weeks). MasterLock 0.25% V/V was added to all treatments.

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

Michigan Potato Industry Commission Grant Proposal 2025 Report

Project Title: Development of suppressive soils for sustainable management of the Potato Early Die complex

Investigator: Marisol Quintanilla

Introduction

Potato early die (PED), caused by the combined activity of Pratylenchus penetrans and Verticillium dahliae, can reduce potato yields by 30–50%. Current PED management strategies, including fumigation, may negatively impact the soil microbiome, limiting the activity of natural biological control systems. Previous research has shown that poultry manure and a compost blend (cattle and poultry manure + wood ash) can significantly reduce P. penetrans populations while improving potato yield. Although the mechanisms behind the pesticidal effects of these amendments are not fully understood, microbial communities are thought to play a key role. In recent decades, compost and manure have gained attention as alternatives to chemical fumigants, showing promise for managing plant-parasitic nematodes. The objective of this study was to evaluate the effects of compost compared with other common management strategies, including chemical and fumigation treatments, on plant-parasitic and free-living nematodes in potato fields.

Materials and Methods

<u>Experimental site and design</u>

The study was conducted at the Lennard Fumigation & Compost Trial (GPS: 41.75967, -85.50634) over the 2024 and 2025 growing seasons. A randomized complete block design with six treatments and four replicates per treatment (24 blocks total) was used. Each block consisted of 10 rows, with a row width of 2.83 ft, block width of 28.3 ft, and block length of 150 ft, covering 4,245 ft^2 per block (total area: 101,880 ft^2). Treatments are described in Table 1.

<u>Nematode sampling and population assessment</u>

Soil samples were collected from each plot at three stages: early season, mid-season, and harvest. Soil cores (~175 cm^3 each) were collected in a zigzag pattern across each plot and combined into a bulk sample (~7 L), which was thoroughly homogenized before subsampling. Nematodes were extracted using a modified centrifugal flotation method, identified to genus or species, and counted under a stereomicroscope. Nematode population changes were expressed as a reproduction factor (RF), calculated as the ratio of final population density to initial population density.

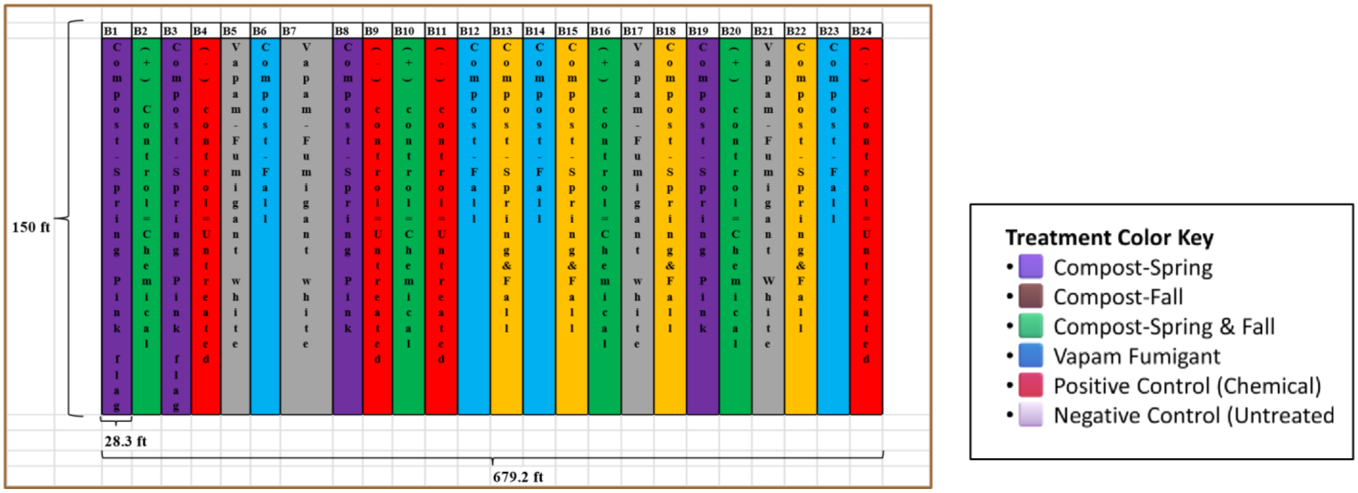

Table 1. Treatments and layout of the study field trial, 2024-2025.

Results

Compost-treated soils generally showed higher free-living nematode reproduction compared with non-compost treatments; however, these differences were not statistically significant (Fig. 1). Vapam-Fumigant White and compost treatments reduced total plant-parasitic nematode reproduction by 63% and 7–26%, respectively, compared with the untreated control (Fig. 2).

Vapam-Fumigant White and compost treatments reduced root-lesion nematode (Pratylenchus penetrans) reproduction by 90% and 52–65%, respectively, compared with the untreated control (Fig. 3).

Applications of Vapam fumigant and compost treatments reduced spiral nematode (Helicotylenchus spp.) reproduction by 51% and 5–13%, respectively, compared with the chemical control. In contrast, compost-fall and untreated control plots showed smaller reductions, ranging from 0% to 26% (Fig. 4).

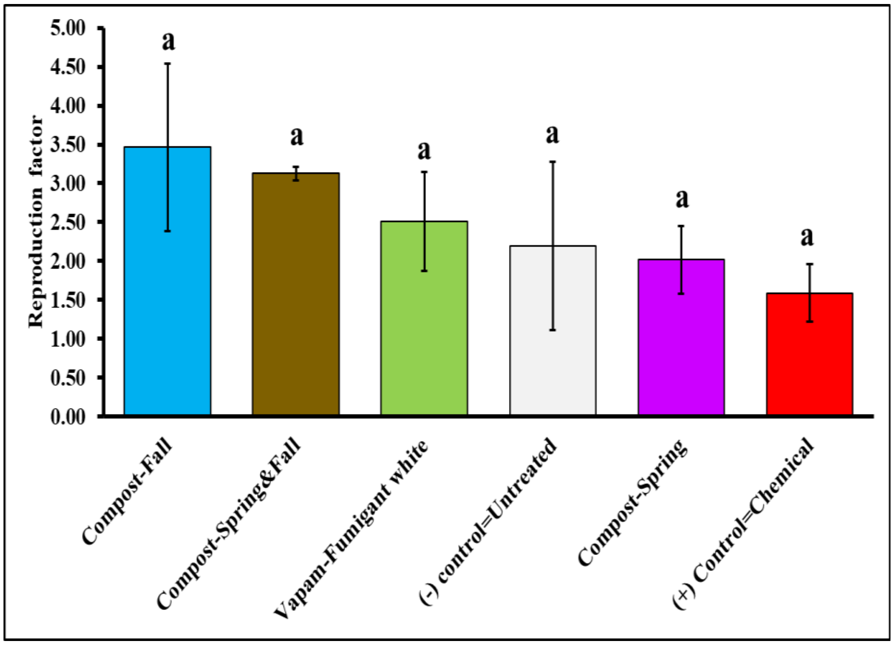

Figure 1. Impact of six soil treatments on free-living nematode reproduction factor in potato. Bars show mean ± SE (n = 3–4). Different letters indicate significant differences (P < 0.05); lack of letters = no significant difference. Field trial, 2024.

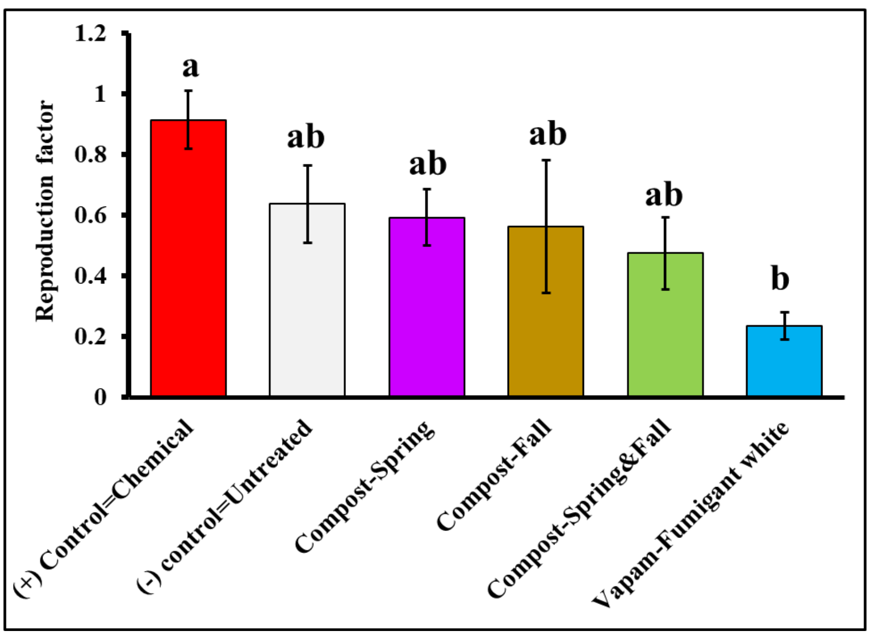

Figure 2. Plant-parasitic nematode reproduction factor under six soil treatments in potato. Bars = mean ± SE (n = 3–4). Different letters indicate significant differences (P < 0.05). Field trial, 2024.

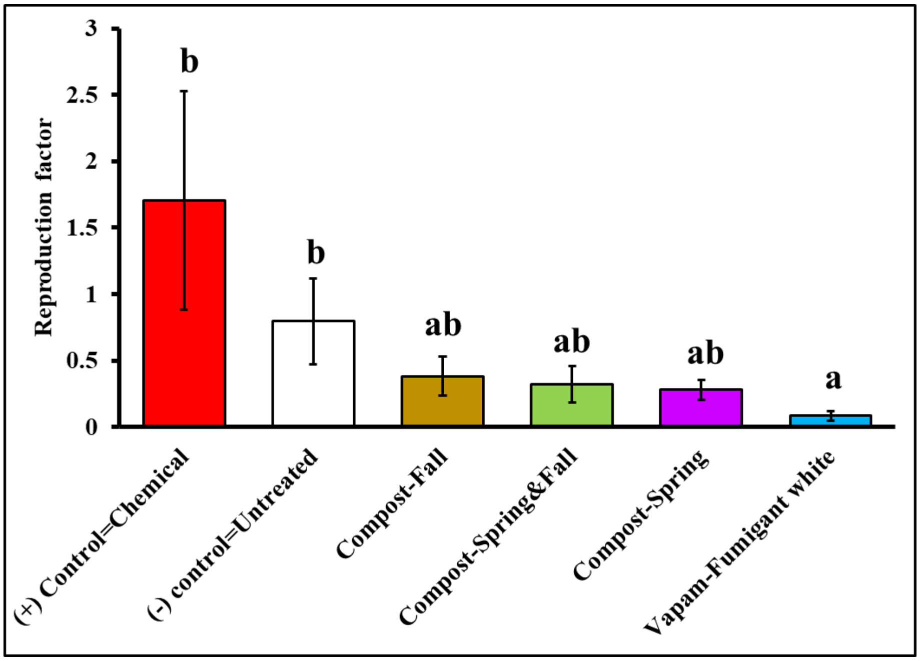

Figure 3. Root-lesion nematode (Pratylenchus penetrans) reproduction factor under six soil treatments in potato. Bars = mean ± SE (n = 3–4). Different letters indicate significant differences (P < 0.05). Field trial, 2024.

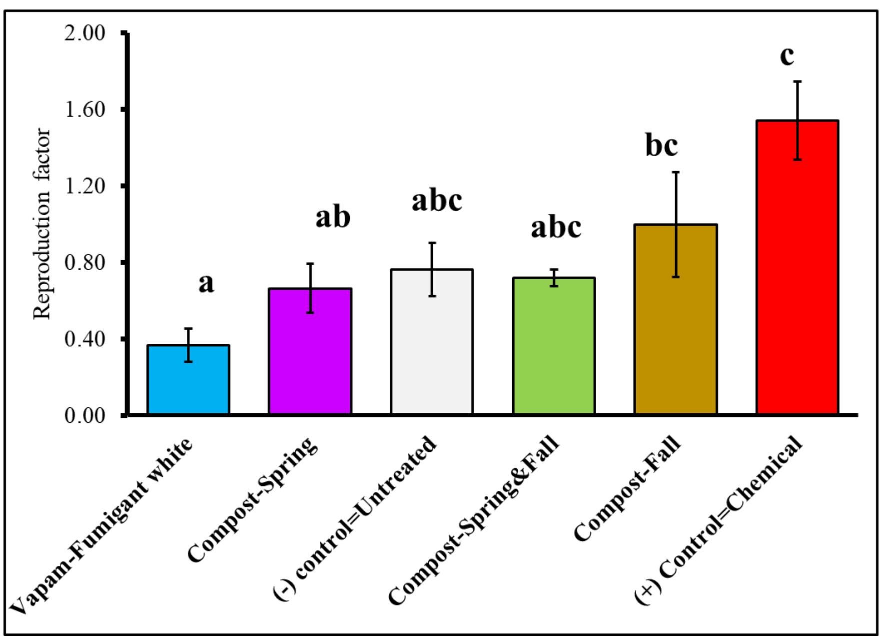

Figure 4. Reproduction factor (RF) of spiral nematodes (*Helicotylenchus* spp.) in potato under six soil treatments; bars show mean ± SE (n = 3–4). Different letters (A, B, C) indicate significant differences among treatments (P < 0.05). Field trial, 2024.

Conclusions

In conclusion, compost amendments resulted in moderate suppression of plant-parasitic nematodes while maintaining or enhancing populations of beneficial free-living nematodes, indicating a potential role in improving soil biological health in potato fields. Although fumigation provided the highest level of nematode control across treatments, compost-based approaches may contribute to integrated nematode management strategies aimed at balancing pest suppression and soil health.

Future Work

Data analysis from the 2025 season is ongoing and will further clarify the effects of compost, chemical, and fumigation treatments on plant-parasitic and free-living nematodes in potato fields. These additional analyses will help strengthen conclusions regarding the role of compost amendments in nematode suppression and soil health enhancement.

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A state-wide assessment to better understand soil health and sustainability in potato-based cropping systems in Michigan

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Introduction

Maintaining soil health is one of the major challenges for farmers across the United States. Potato farming is particularly detrimental to soil health because of intensive tillage, frequent physical soil disturbance, and use of external chemical inputs (Hills et al., 2020). There are a number of management strategies that can improve soil health in potato systems. This includes reducing tillage and implementing cover crops, having a high diversity crop rotation and incorporating organic amendments (Carter et al., 2009; Hills et al., 2020). That said, to date we have a poor understanding of how to efficiently improve soil health across Michigan potato farms which have very sandy, coarse textured soils. Additionally, potato growers still have to contend with disease and plant parasitic nematodes which often require the use of pesticides to manage. Fumigants, specifically, can be even more detrimental to soil health in potatoes. The goal of this study is three-fold: 1) assess soil health characteristics on potato farms across the state of Michigan 2) identify which management practices are most effective at improving soil health across the state of Michigan and 3) identify how soil health metrics change over the growing season.

Method

Site Selection and Soil Sampling

In 2025, we sampled 50 fields from Michigan (Figure 1). Farm fields were selected based on management style, geographical location, and soil type. Emphasis was placed on selecting a range of farms using a range of different management styles. For example, farms using lower than average tillage, cover cropping and diverse crop rotations were considered low intensity and farms using average or higher than tillage, no cover crops and short rotations were considered more intensive. Farmers were asked for management surveys in 2025, these are still incoming.

Soil samples were collected from one location within each field using a grid sampling approach. Samples were taken at 20 cm in depth using a 1.91 cm diameter soil probe There were two sampling timepoints, pre-plant and 60 days after planting (60DAP). Pre-plant samples were taken approximately 1 week to 1 day before planting. Each farmer received a soil health report for each field (Appendix 1).

Soil processing for soil health metrics

Before analyses, soils were sieved at 2 mm and air dried. Soil texture was measured by treating the soil with sodium hexametaphosphate and using a hydrometer to measure the density of soil particles in suspension (Gee and Bauder, 1986). Soil health indicators included soil protein, POXC and mineralizable C (Table 1). POXC was quantified by methods adapted from Weil et al. (2003) and Culman et al. (2012). Soil protein was quantified by methods adapted from Hurisso et al. (2018) and Moebius-Clune et al. (2016). Lastly, mineralizable C was quantified via a 24-h assay measuring CO_2 respired from rewetted (Franzluebbers et al., 2022; Hurisso et al., 2016).

Nematode quantification and identification

Nematodes were extracted from 50 g of soil using the Baermann funnel extraction method (Baermann, 1917). Extracted nematodes were fixed in 4% formalin. Nematode abundance was quantified using an inverted microscope. For each sample the first 100 nematodes were identified to the trophic group and genus. Nematode indices were calculated using Nematode Indicator Joint Analysis (NINJA), a software program that calculates nematode indices based on colonizer-persister values of each nematode family group (Table 1) (Sieriebriennikov et al., 2014). Metabolic footprint was created by plotting the structure index against the enrichment index.

Statistical Analyses

All analyses were performed using R software (R Core Team, 2021). Mean and standard deviation of soil nutrient levels for each farm was reported in Table 2.

We have yet to receive management surveys, yield, and quality metrics from every farm involved in the study. That said, once those metrics are received, those metrics will be further incorporated into our analysis. Most farmers used the same management for every field. To reflect management and determine if soil health parameters vary, we will use farm as a proxy. General linear mixed models (glmmTMB) were used to determine if soil health parameters and nematode indices differed by farm management (main factor), time (subfactor), soil texture (subfactor) or the relationship between time and farm (subfactor). DHARMa and Shapiro tests were used for model verification. ANOVA and emmeans using Tukey's HSD were used for post-hoc analyses. For all models, county was nested within region and treated as a random effect. Significance was set at $P<0.05$.

Non-metric multidimensional scaling (NMDS) using Bray-Curtis dissimilarity matrices were used to determine compositional differences for nematode communities at the genus level. Permutational analysis of variance (PERMANOVA) was used to identify how farm, timepoint, and the interaction affect composition. All plots were created in ggplot.

Results and Conclusions

Soil Health Metrics

Soil protein, organic matter percentage, POXC and mineralizable C were all significantly influenced by farm management (Figure 2; Table 3). All farms had relatively low levels of organic matter. However, these rates were not affected by time or the interaction of time and farm. On average, pre plant soils were 1.26% and post plant were 1.24% organic matter. This may indicate that management does not decrease organic matter during the growing season. UP2, a less intensive farm, had consistently high soil protein, POXC and mineralizable C. Farms from the central region, which tend to be more intensive, had consistently low values of these metrics. POXC and mineralizable C decreased in most farms. This indicates a decline in organic carbon over the potato growing season. At most farms, soil protein slightly increased within the growing season. This is likely a result of fertilizer application and efficiency of the microbial community in cycling N. Soil texture only affected measures of soil organic carbon (i.e., POXC and mineralizable C).

Generally, soil health metrics appeared to vary depending on farm management. Based on conversations with farmers, the more intensive farms tended to have slightly lower soil health while those using less intensive management had higher soil health. However, this was variable depending on the specific metric. Certain management practices, such as fertilizer application and time, can significantly affect soil health metrics during the growing season but may not reflect long term gains in soil health. After receiving the management surveys, we will determine which strategies correlate to high soil health, yield and potato quality.

Energy was affected by farm (χ^2=56.22, P<0.0001), time (χ^2=10.71, P=0.001), and the interaction of time and farm (χ^2=24.62, P=0.026) but not soil texture (χ^2=1.99, P=0.37) (Figure 3). However, most values of total C:N ranged from ~10 to 18. These fall within the normal range for agricultural fields.

Nematode Community

All community indices were affected by farm management and time or the interaction of farm and time (Figure 4, Table 4). Only the channel and basal indices were affected by soil texture. Maturity and structure indices were most negatively affected by time with values decreasing over the growing season. Nematode-based soil health indices did not correlate to soil protein, organic matter percentage, POXC, and mineralizable C. There was a high degree of variability within the farms and regions. UP2 (less intensive) had average values for all indices, whereas some of the central farms (more intensive) had the highest values of certain indices. Nematodes can be more sensitive to physical disturbance and have a slower regeneration time than bacteria and fungi. These indices likely represent longer term soil health.

Almost all nematode communities had a metabolic footprint that fell into the bottom left quadrat (Figure 5). This indicates that the community is disturbed and conducive to plant parasitic nematodes. Two farms from central and NW had matured communities' pre-plant that deteriorated over the season. One farm from the UP moved from disturbed to maturing, which is highly unusual given the physical disturbance in potato farming. Management surveys are needed to identify further patterns in nematode indices and the metabolic footprint.

Compositionally, farm, time and the interaction of the two structured nematode communities (Figure 6). Most soil samples consisted predominantly of bacterivore nematodes at both time points (Figure 7). Bacterivores accounted for ~50% of most communities. Fungivores accounted for ~5-10% and omnivore/predator nematodes for ~1-5% of communities. Herbivores typically comprised 5-30% of communities. There were no herbivores in the UP3 post plant community. The most common plant parasitic nematode genus identified within soil was *Pratylenchus* spp. (Figure 8A). There was a high degree of variability in the number of *Pratylenchus* spp. in each farm and over time (Figure 8B). Several farms' populations decreased or increased with most remaining consistent. Interestingly, UP2 (less intensive) had a low number of *Pratylenchus* spp. and many central farms (more intensive) had high numbers. Most of the other highly abundant herbivores were from the family Tylenchidae (i.e., Filenchus, Tylenchus, Malenchus) which are often referred to as root-associates that do not typically cause plant disease in potatoes. These nematodes are important for carbon and nitrogen cycling and plant growth. Other plant parasitic nematodes that are known to cause disease in potatoes were found in low numbers (Figure 8A). These include *Heterodera*, *Trichodorus*, *Paratrichodorus*, *Melodogyne*, and *Xiphenema*. There was one farm, Thumb1, that had a high number of *Heterodera* spp. post plant.

Conclusion:

Generally, soil health decreased over time. Farm management and time were the major factors driving soil health variables. Most farms had a decrease in soil carbon (i.e., POXC and mineralizable carbon) over the course of the growing season. Soil nitrogen was more variable but may have been influenced by fertilization rates and timing. Energy (i.e., total C:N) and organic matter was consistent. Nematode indices were variable, but tended to decrease over time. Indices and the metabolic footprint indicated depleted and disturbed nematode communities across most farms. This was further supported by composition, where nematode communities were largely bacterivores and herbivores. There were often low percentages of higher trophic level taxa. Plant parasitic nematodes were present in most farms, but the population sizes were variable. The most common plant parasite was *Pratylenchus* spp. followed by *Heterodera* spp. Future work will use management surveys to identify which management practices were most effective in retaining soil health over the growing season and which soil health variables correlated most highly to yield and quality. Lastly, individual farms have received soil health test reports for each field (Appendix 1). Our team is more than happy to provide consultations to any farmer wanting further information on their soil health test reports.

Figure 1: Potato fields sampled in 2025. Each dot represents one field for a total of 50 fields. Soils were sampled prior to planting and 60 days after planting for a total of 100 soil samples. Each color of the dot represents the region. Abbreviations: NW = Northwest; SW = Southwest; UP = Upper Peninsula.

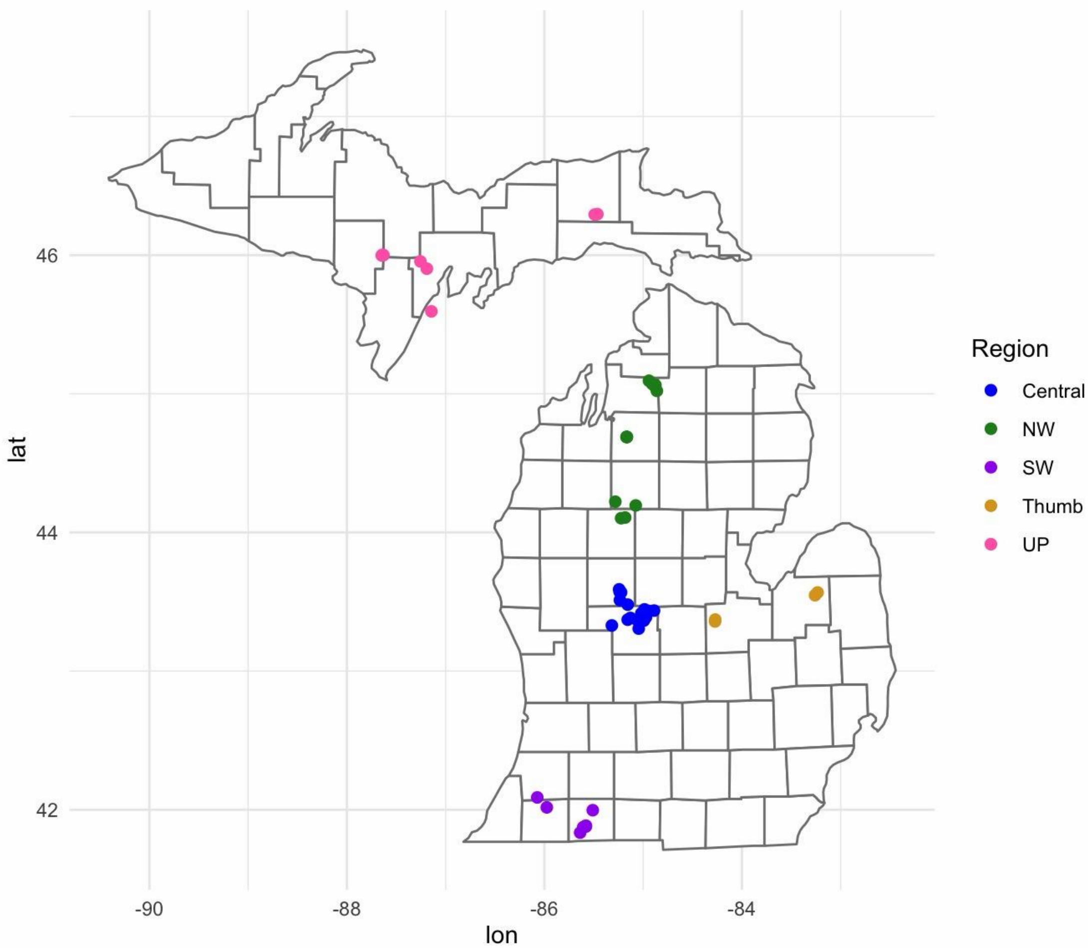


Table 1: Description of soil health metrics and nematode community indices.

Soil Health Metric	
Soil Protein	Soil nitrogen availability; high numbers indicate higher availability
Organic Matter %	The amount of organic matter in soil. 5% or higher is great, 3-6% is ideal for agriculture and under 2% is very low.
POXC	Permanganate oxidizable carbon represents a portion of the organic carbon pool in soils.
Mineralizable C	A different portion of the organic carbon pool in soils. Often correlates to microbial activity.
Nematode Indices	
Maturity Index	Reflects disturbance of soil. High values indicate high rates of disturbance.
Channel Index	Indicates if decomposition is fungal- or bacterial-pathway dominant. Values >50 are fungal and <50 are bacterial. Fungal pathways typically break down complex organic matter slowly.
Basal Index	Reflects food web structure and complexity. Low values indicate a stable, complex food web and high values indicate a depleted, damaged food web.
Enrichment Index	Reflects food availability and nutrient enrichment. High values indicate more food availability.

Structure Index	Reflects soil food web and disturbance via chemical or physical pathways. High values indicate a structured food web and low values indicate a perturbed food web.

Table 2: Mean and standard deviation of soil nutrient analyses of each farm.

		CEC		pH		Phosphorous		Potassium		Magnesium		Calcium		Sulfur		Boron		Copper		Iron		Manganese		Zinc	
Acronym	Timepoint	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Central1	Pre-plant	3.9	0.6	6.0	0.9	141.3	17.2	149.3	69.4	106.0	34.4	493.3	124.0	24.7	16.6	0.8	0.2	2.7	1.2	186.7	22.4	42.7	18.0	4.2	0.5
	60DAP	4.0	0.4	5.1	0.6	211.0	41.8	110.3	26.8	123.3	45.8	549.7	204.2	54.0	7.5	0.7	0.1	3.8	1.4	226.3	14.2	57.3	14.4	5.5	2.1
Central2	Pre-plant	4.6	1.2	6.4	0.6	247.3	96.4	108.0	42.6	89.3	14.0	834.3	190.2	10.0	2.6	0.7	0.3	3.5	2.0	254.7	35.7	63.3	5.0	5.7	2.4
	60DAP	6.4	2.7	6.2	0.7	246.0	115.7	150.7	51.1	130.3	65.8	1080.7	308.3	43.7	21.0	0.8	0.2	4.5	2.8	261.0	55.0	64.7	6.1	7.0	5.6
Central3	Pre-plant	3.9	0.9	6.3	0.4	277.0	110.2	179.3	42.4	116.5	10.7	665.5	133.4	16.0	6.6	0.6	0.0	3.2	1.3	251.3	13.1	58.0	12.9	6.9	3.3
	60DAP	3.2	0.5	5.7	0.3	247.0	96.1	153.0	26.0	105.0	20.8	553.0	105.6	53.5	12.1	0.8	0.1	2.6	1.4	235.8	25.5	49.5	13.0	6.6	3.5
Central4	Pre-plant	3.7	0.3	6.5	0.2	152.3	14.4	157.0	29.1	110.0	11.3	632.7	89.2	21.7	12.5	2.0	1.6	1.4	0.8	199.3	9.3	50.3	7.4	5.8	2.1
	60DAP	4.2	0.4	6.0	0.6	192.3	30.7	157.0	84.5	108.0	9.8	735.3	43.2	48.3	26.6	1.1	0.4	2.0	1.2	221.0	28.6	48.0	19.3	6.3	2.5
Central5	Pre-plant	3.0	0.7	6.0	0.2	180.0	61.1	124.0	37.3	78.3	15.1	562.5	153.7	15.0	10.1	0.6	0.1	1.9	1.3	238.0	46.9	48.3	21.2	4.0	1.7
	60DAP	3.5	0.5	5.8	0.2	252.0	65.1	164.0	26.9	108.5	16.3	635.3	103.0	60.5	32.3	0.7	0.1	3.0	1.9	238.0	38.4	65.8	11.6	5.5	1.8
NW1	Pre-plant	6.0	3.3	4.9	0.5	95.0	66.1	89.7	80.0	73.3	33.0	339.3	109.7	63.3	60.1	0.7	0.1	0.3	0.2	235.3	44.8	51.7	39.2	3.5	2.9
	60DAP	2.4	1.0	4.9	0.2	125.3	68.1	44.0	15.6	46.3	11.7	320.7	80.4	25.7	7.4	0.7	0.0	1.3	1.5	232.3	17.2	63.7	45.5	4.6	2.3
NW2	Pre-plant	4.2	0.8	6.5	0.3	135.3	70.6	96.0	12.7	99.3	19.7	749.0	85.2	14.0	10.8	0.9	0.2	2.4	1.3	206.8	38.2	48.0	26.2	5.8	2.6
	60DAP	4.1	0.5	5.7	0.3	169.3	70.7	109.0	16.9	138.8	20.1	761.0	131.1	90.8	22.9	0.6	0.0	3.1	1.4	227.3	48.3	57.8	12.6	7.4	0.3
NW3	Pre-plant	4.0	1.4	6.0	0.3	178.8	84.0	144.3	21.2	94.0	18.9	798.3	345.2	25.3	12.3	0.6	0.0	5.2	0.9	266.3	60.5	59.8	12.3	8.8	3.0
	60DAP	3.8	0.8	5.5	0.2	213.8	107.5	109.3	17.3	80.5	23.2	710.8	265.1	68.0	49.1	0.8	0.1	6.0	1.8	242.0	52.8	55.3	14.7	8.5	1.7
NW4	Pre-plant	3.2	0.4	6.2	0.4	208.0	2.8	73.0	12.7	76.5	10.6	646.5	103.9	8.5	0.7	0.6	0.0	5.4	5.0	271.0	8.5	42.5	16.3	10.7	5.4
	60DAP	4.7	0.8	6.1	0.7	277.5	48.8	122.5	14.8	117.0	17.0	811.5	16.3	18.0	0.0	1.5	0.2	6.1	7.1	276.5	64.3	46.0	1.4	11.4	2.3
SW1	Pre-plant	4.2	1.4	6.2	0.5	136.9	45.1	136.7	29.7	110.9	24.1	788.3	256.1	33.6	13.4	0.5	0.1	2.6	2.1	191.4	34.5	96.4	46.4	5.9	2.6
	60DAP	4.6	1.6	6.2	0.4	164.7	56.3	127.7	33.0	122.6	28.4	885.9	277.0	52.1	17.3	1.1	0.3	3.4	3.2	202.9	27.1	103.7	42.7	6.9	2.6
Thumb1	Pre-plant	6.8	1.8	6.8	0.3	133.0	48.2	161.8	106.8	127.5	17.6	1225.0	485.5	63.3	94.8	0.7	0.1	3.2	2.8	192.8	39.7	35.5	27.9	7.8	2.7
	60DAP	7.4	2.8	7.1	0.2	150.0	63.6	134.5	45.8	167.0	64.2	1362.3	491.4	21.8	15.4	1.2	0.5	3.9	2.9	182.0	34.4	51.0	34.5	10.7	5.1
UP1	Pre-plant	5.7	2.3	6.4	0.5	315.8	74.3	139.3	30.6	223.5	86.7	981.8	392.6	7.8	1.5	0.7	0.1	1.9	0.6	255.3	28.0	74.3	24.6	4.5	1.3
	60DAP	10.2	1.4	6.5	0.6	330.3	39.6	152.5	18.2	288.8	94.6	1417.8	220.9	12.0	2.2	0.8	0.1	1.9	0.7	244.5	31.6	92.8	11.2	5.2	1.5
UP2	Pre-plant	7.6	1.8	6.6	0.4	59.7	39.2	95.7	19.5	159.0	16.5	1415.7	303.0	15.0	2.0	0.7	0.2	1.1	1.1	221.3	41.5	54.0	21.3	2.3	0.8
	60DAP	10.4	5.5	6.4	0.7	57.0	20.4	95.3	34.6	181.0	42.6	1974.0	1144.5	28.3	5.9	0.7	0.1	1.1	1.4	206.3	8.1	83.7	30.0	2.8	0.5
UP3	Pre-plant	4.3	0.6	6.5	0.4	305.5	30.4	103.0	32.5	97.0	24.0	784.5	3.5	29.0	21.2	0.6	0.1	2.6	0.1	166.5	12.0	31.0	5.7	4.8	0.3
	60DAP	3.1	0.8	6.1	0.2	300.0	12.7	68.0	5.7	80.0	31.1	635.5	159.1	32.5	17.7	1.0	0.4	2.5	0.9	160.0	12.7	24.5	2.1	4.6	0.3

Figure 2: Soil protein, organic matter %, POXC, and mineralizable C from potato farms in Michigan. Color represents region and pattern indicates timepoint. Values below the red dashed line are considered low, those above the green line are high or very high and those in between are average.

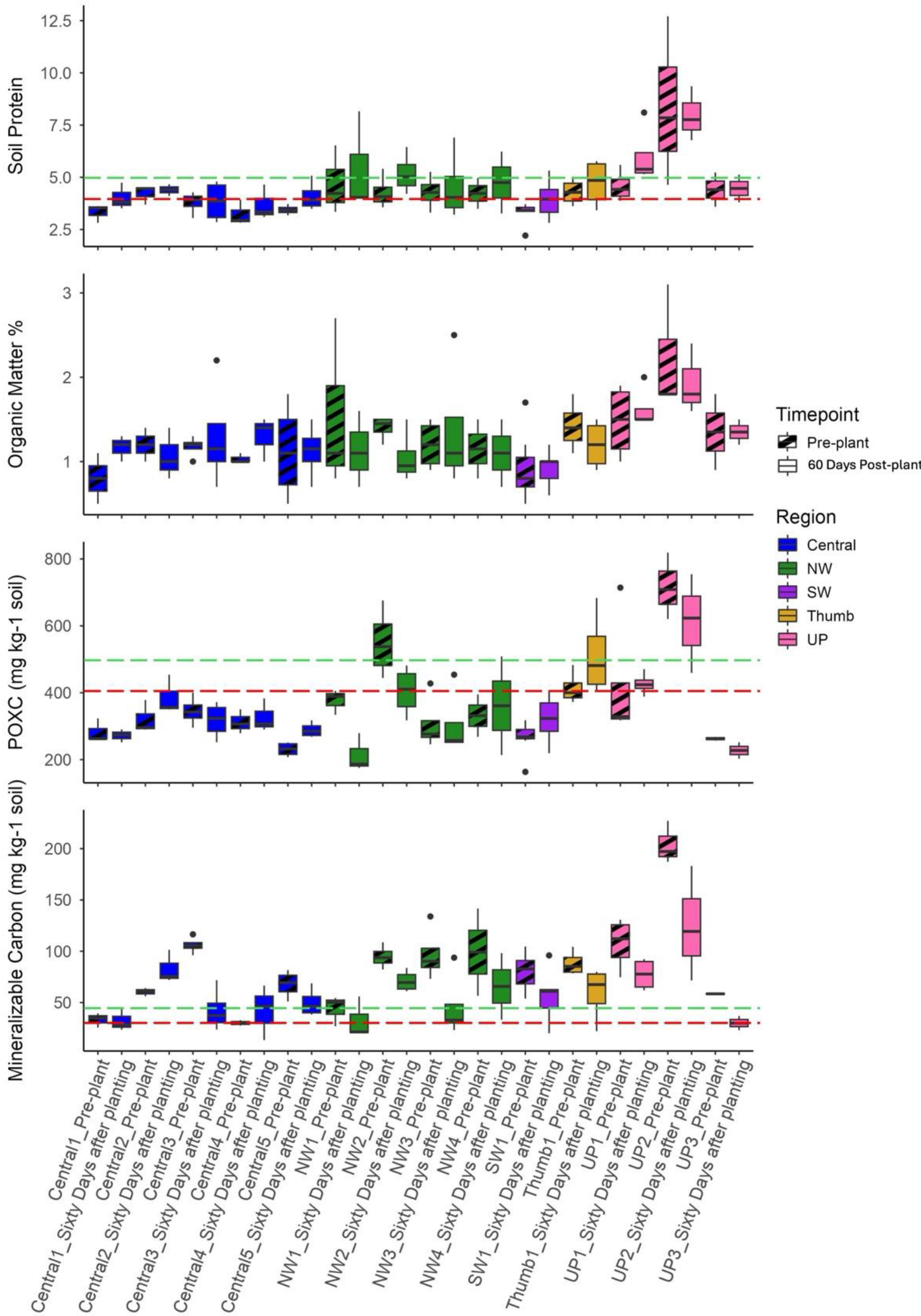


Table 3: Results of a general linear mixed model used to determine how soil health metrics (dependent variable) were affected by farm, time, soil texture or the relationship between time and farm (independent variables). In the model, county was nested within region and used as a blocking term to account for geographic patterns. Bolded values are significant (P<0.05).

	Farm		Timepoint		Soil Texture		Timepoint*Farm	
	P	χ^2	P	χ^2	P	χ^2	P	χ^2
Soil Protein	**<0.0001**	**83.89**	**0.003**	**8.89**	0.28	2.55	0.99	4.15
Organic Matter %	**0.0001**	**40.55**	0.96	0.003	0.90	0.21	0.7	9.80
POXC	**<0.0001**	**197.0**	0.88	0.02	**0.007**	**9.99**	**<0.0001**	**41.5**
Mineralizable C	**<0.0001**	**116.28**	**<0.0001**	**44.31**	**0.005**	**10.48**	**0.005**	**29.80**

Figure 3: Total Carbon:Nitrogen Ratio (i.e., energy) from potato farms in Michigan. Color represents region and pattern indicates timepoint. Farm soils typically have values between 10 and 20.

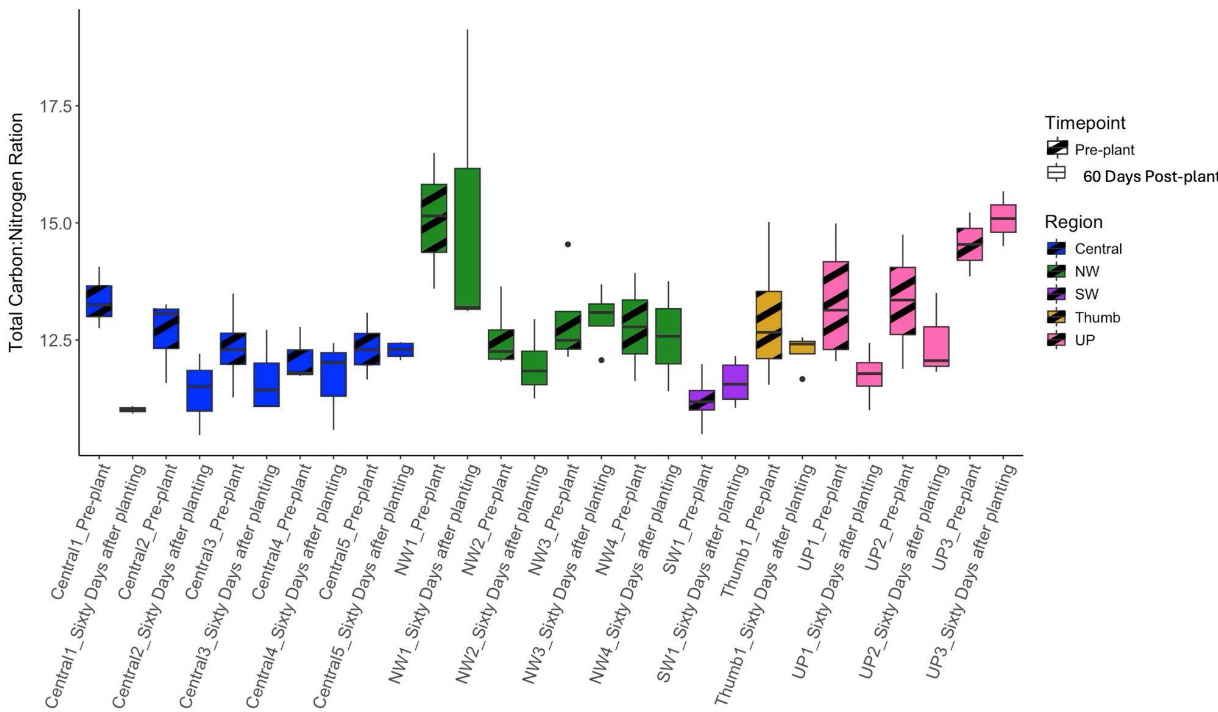


Figure 4: Nematode community indices (Maturity, channel, basal, enrichment and structure index) from potato farms in Michigan. Color represents region and pattern indicates timepoint.

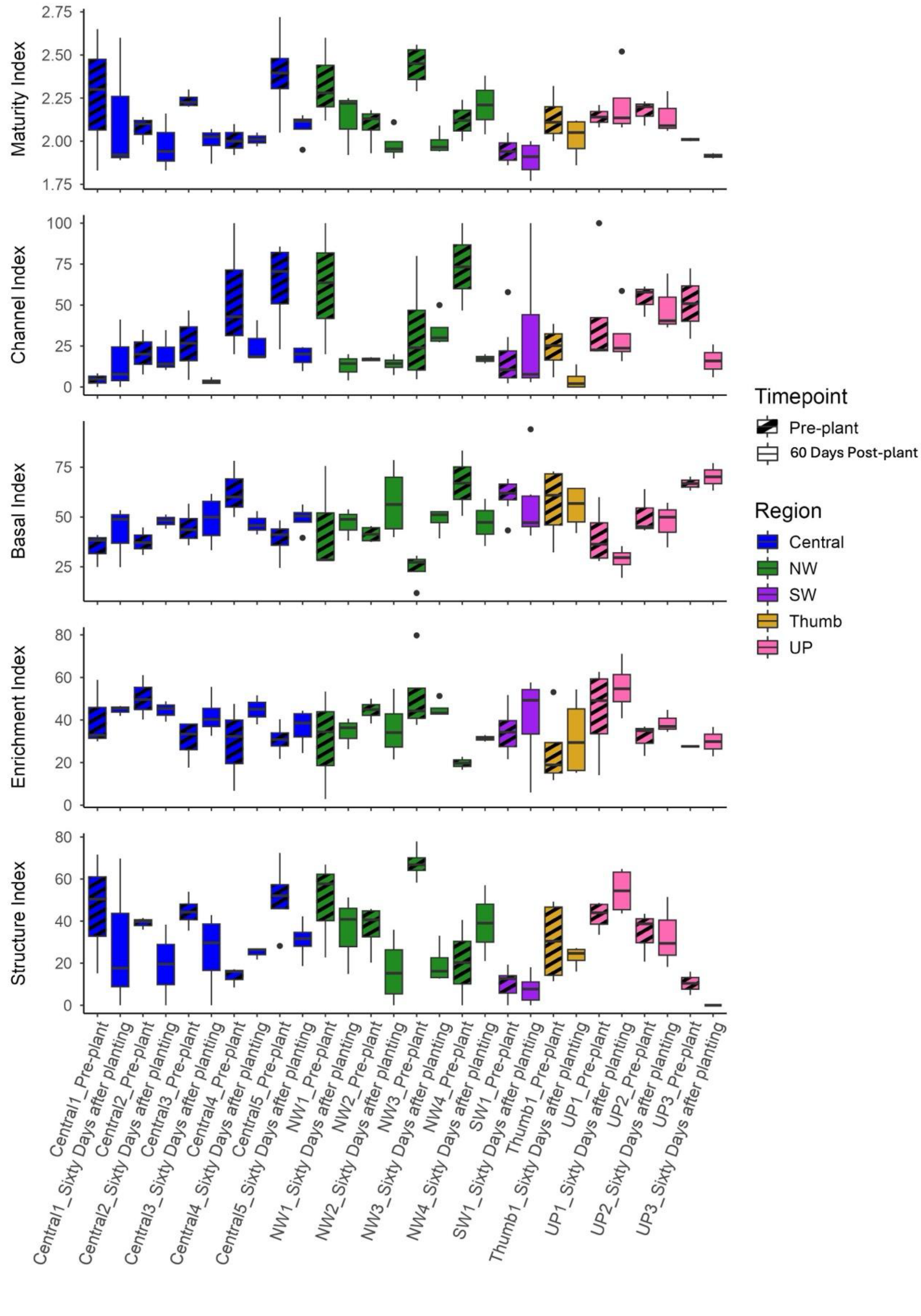


Table 4: Results of a general linear mixed model used to determine how nematode indices (dependent variable) were affected by farm, time, soil texture or the relationship between time and farm (independent variables). In the model, county was nested within a region and used as a blocking term to account for geographic patterns. Bolded values are significant (P<0.05).

	Farm		Timepoint		Soil Texture		Timepoint*Farm	
	P	χ^2	P	χ^2	P	χ^2	P	χ^2
Maturity Index	**<0.0001**	**64.95**	**<0.0001**	23.48	0.23	2.92	**0.017**	**26.08**
Channel Index	**<0.0001**	**78.71**	**0.0003**	13.41	**0.0002**	**16.86**	**<0.0001**	**41.52**
Basal Index	**<0.0001**	**63.23**	0.317	0.99	0.09	4.82	**0.006**	**29.43**
Enrichment Index	**0.02**	**25.69**	**0.04**	**4.19**	0.27	2.47	0.73	9.58
Structure Index	**<0.0001**	**67.31**	**0.0002**	**14.10**	0.26	2.70	**0.0008**	**35.11**

Figure 5: Metabolic footprint of nematode communities. The color indicates the farm and region with brown shades being central, green being northwest, blue being southwest, orange being the thumb and pink being the Upper Peninsula. The shape indicates the time point with circles being pre plant and triangles being 60 DAP. Each quadrat represents characteristics of the soil. The top left quadrat indicates highly disturbed soil, the bottom left indicates degraded soil, the top right indicates the soil is maturing and bottom right indicates it is matured.

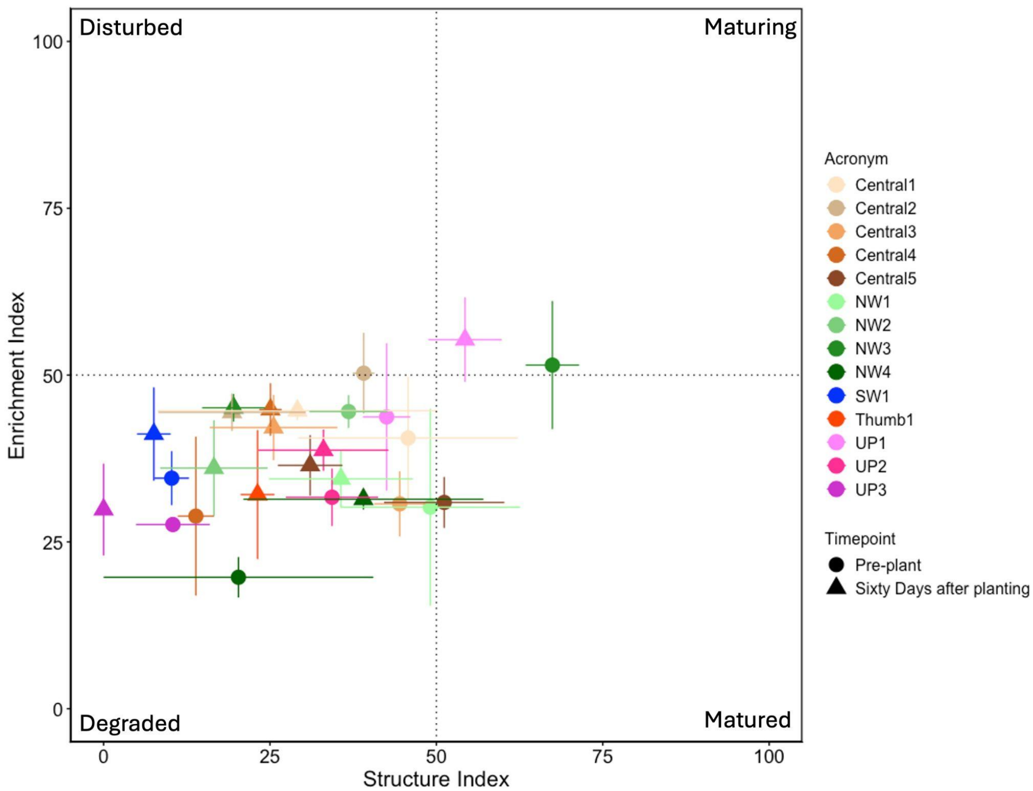
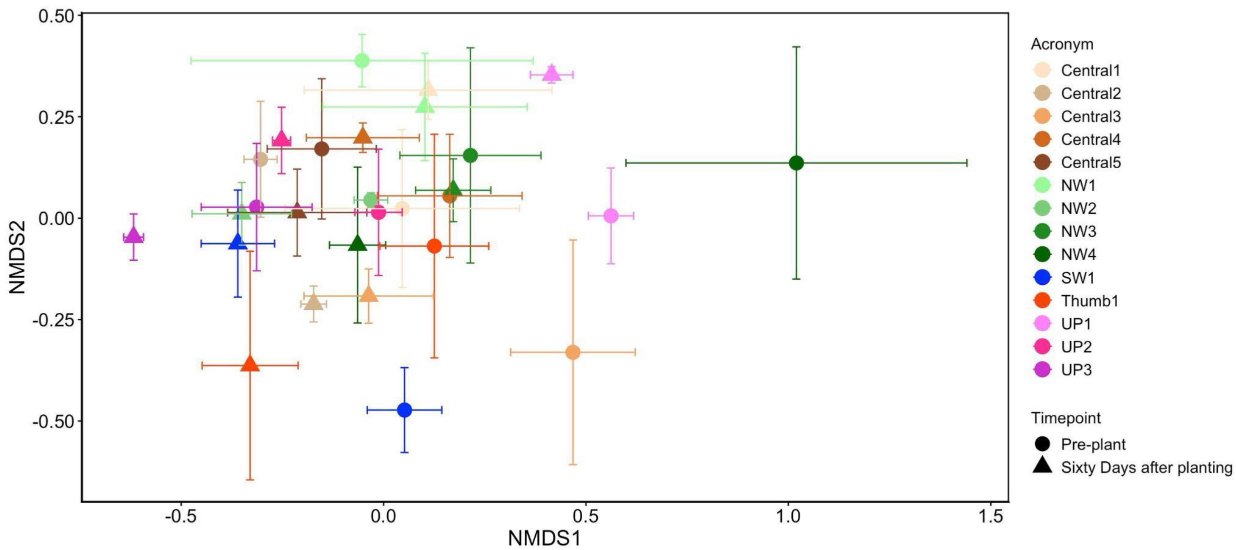


Figure 6: Ordination of nematode communities in an NMDS. The color indicates the farm and region with brown shades being central, green being northwest, blue being southwest, orange being the thumb and pink being the Upper Peninsula. The shape indicates the time point with circles being pre plant and triangles being 60 DAP. Differences in community composition were calculated with PERMANOVA.



	R^2	F	P
Farm	0.28	2.96	0.001
Timepoint	0.05	6.43	0.001
Farm*Timepoint	0.14	1.40	0.006

Figure 7: Relative abundance of nematodes at the trophic level. Color indicates the trophic group with blue being bacterivores, green being herbivores, pink being fungivores, grey being predators, and yellow being omnivores. The solid color bars are pre plant and the bars with dots are 60 DAP.

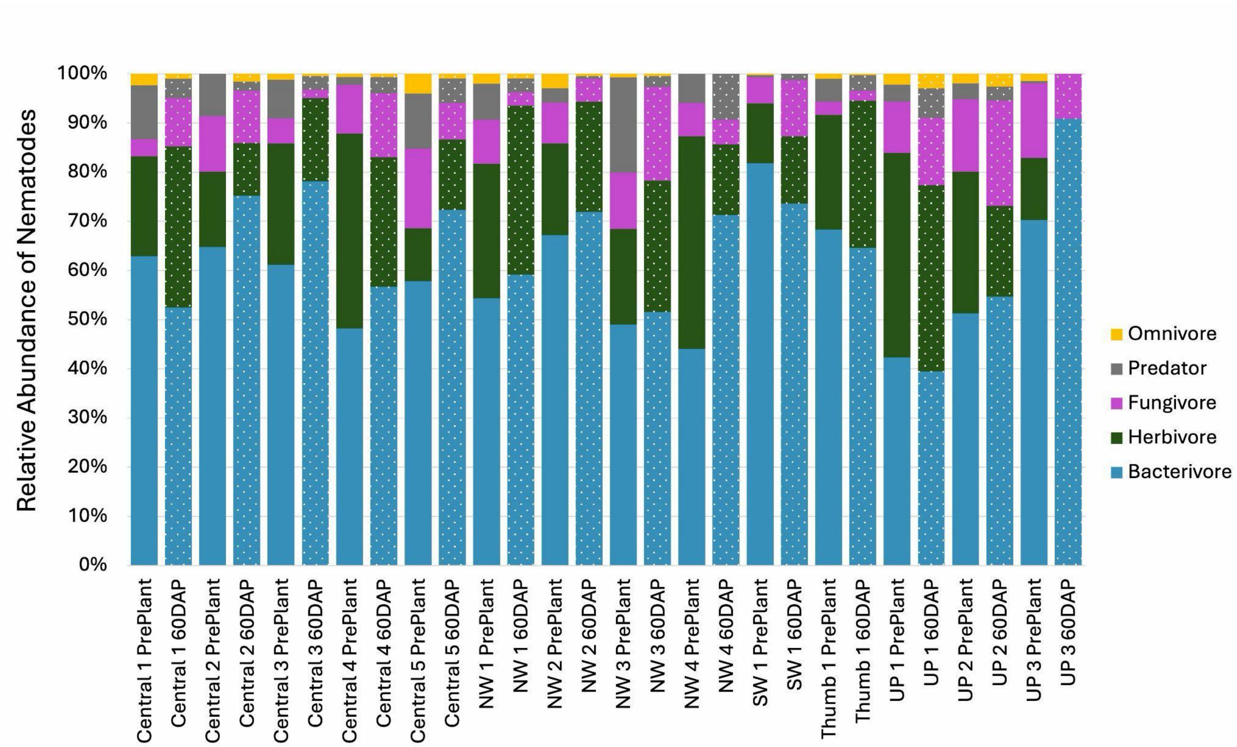
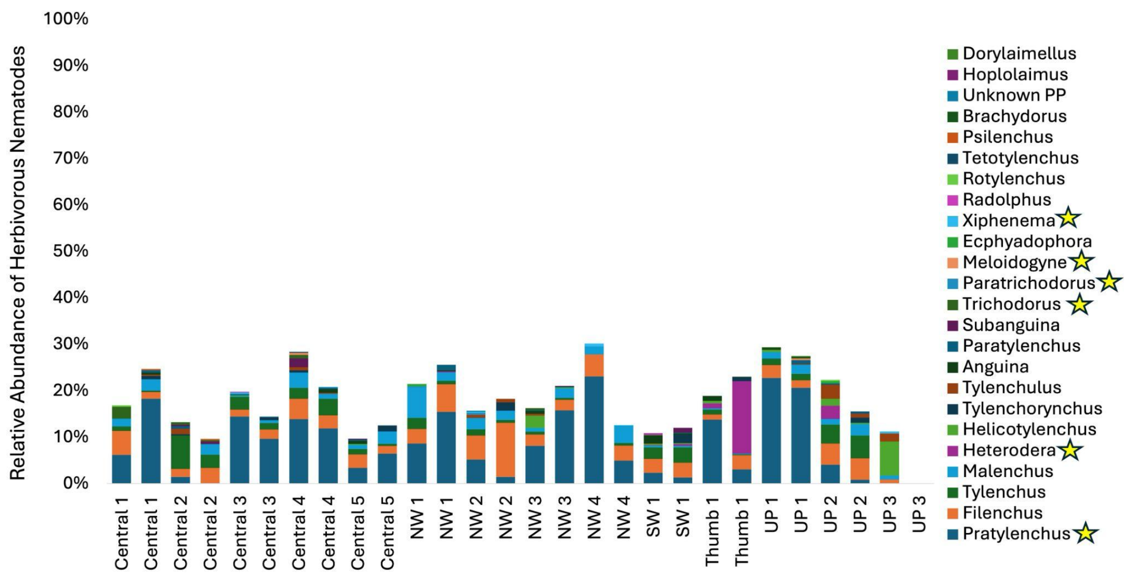
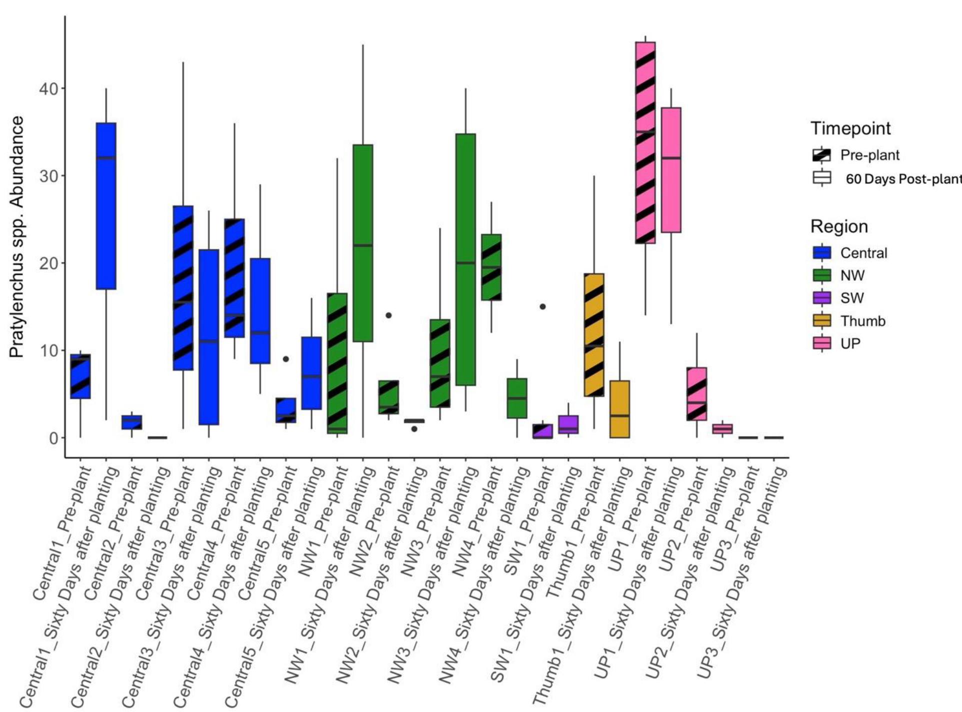


Figure 8: A) Relative abundance of herbivore and plant parasitic taxa in soils. Stars indicate plant parasitic nematodes previously identified as having potential to cause yield losses in potatoes. B) *Pratylenchus* spp. populations in potato farms. The color indicates region and the pattern of the bar indicates time of sampling. These values indicate the relative abundance of Pratynechus in 50 g of soil. The nematodes were identified at the genus level.

A)



B)



Appendix 1:

Soil Health Report

Field Name #: field 76 YEAR: 2025

Thank you for your participation in our soil health study. The MSU Sprunger Lab conducted the following soil health tests for your samples: Routine Soil Nutrients (pH, CEC, OM%), tests that measure soil biology (nematodes), tests that measure the physical structure of the soil (Texture), tests that measure different pools of organic matter (Protein, POXC, Respiration) and energy demand (C:N).Soil sample descriptions from your farm and the corresponding data are below:

Pre-Plant – Sample taken prior to planting
60DAP – Sample taken 60 days after planting

Routine Soil Nutrient Report:

Table 1. Routine soil nutrient test results for your field at Pre-Plant. All nutrients are displayed in parts per million (ppm) units using the Mehlich-3 method unless otherwise specified. The expected ranges come from Spectrum Analytical soil testing lab.

	Pre-Plant	Expected Range
Soil pH	5.8	*6.0-7.0, for most crops
CEC	3.7	Varies
Organic Matter (%)	1.8	See interpretation
K/Mg ratio	1.25	
Ca/Mg ratio	7.63	
P	157	50-80 ppm
K	119	140-240 ppm
Mg	95	160-300 ppm
Ca	725	1200-1800 ppm
S	10	**20-40 ppm
B	0.8	**1.7-2.6 ppm
Cu	2.8	**Varies
Fe	273	**65-185 ppm
Mn	69	**Varies
Zn	5.6	**3.9-10.9 ppm

*Soil pH is a very important measurement. You can fertilize as much as you like, but if your pH isn't optimized, nutrient availability will be restricted. Optimal pH ranges vary depending on crop. **Although soil testing labs often give optimal ranges for sulfur and micronutrients, 'recommended ranges' have not been established through university guidelines for Mehlich-3 extractant.

Organic Matter Test Report:

We measured different parts of the total pool of organic matter. Soil protein is a measure of a large nitrogen pool found within soil organic matter. POXC reflects a pool of carbon that is less accessible to microbes and serves as an early indicator of soil organic matter accumulation. Lastly, respiration is a measure similar to the Haney test or Solvita test that measures the CO_2 respired by the microbes; this gives indication of the microbial activity and the pool of carbon that is most accessible to microbes.

Table 2. Previously observed ranges for soil organic matter indicators for your soil type. The Protein, POXC, and Respiration ranges were calculated based on over 1,000 data points from farms across Ohio, Michigan, Indiana, and Pennsylvania. The following ranges are determined by CEC values.

	Low	Medium	High	Very High
Protein *(g/kg soil)*	2-4	4-5	5-6	6+
POXC *(mg/kg soil)*	56-404	404-496	496-598	598+
Respiration *(Total Min C/g soil)*	5-32	32-43	44-60	60+

Table 3. Pools of organic matter for your samples. The level (low, medium, high) corresponds to where the sample falls within observed ranges for each of these pools (Table 2).

	Pre-Plant	60DAP
Protein	3.5 (Low)	4.11 (Medium)
POXC	207(Low)	268 (Low)
Respiration	51 (High)	52 (High)
Total Carbon/Nitrogen	11.095	12.178

Interpretation:

Protein: *Soil protein was low preplant and increased to average post-plant. This may be indicative of a gain in nitrogen throughout the season. However, it may also be influenced by fertilizer rates and timing. Regardless, soil nitrogen is not yet building for long-term gains.*

Carbon: *Generally, the percentage of organic matter and POXC are low. Respiration (which can reflect organic matter) was high. This might indicate that organic carbon is being used rapidly and the long-term supply is depleted.*

Energy: *The C:N ratio is good and increases slightly over the growing season. It appears the microbial community is active and decomposing readily. However, it is unlikely that there is carbon building for long-term gains.*

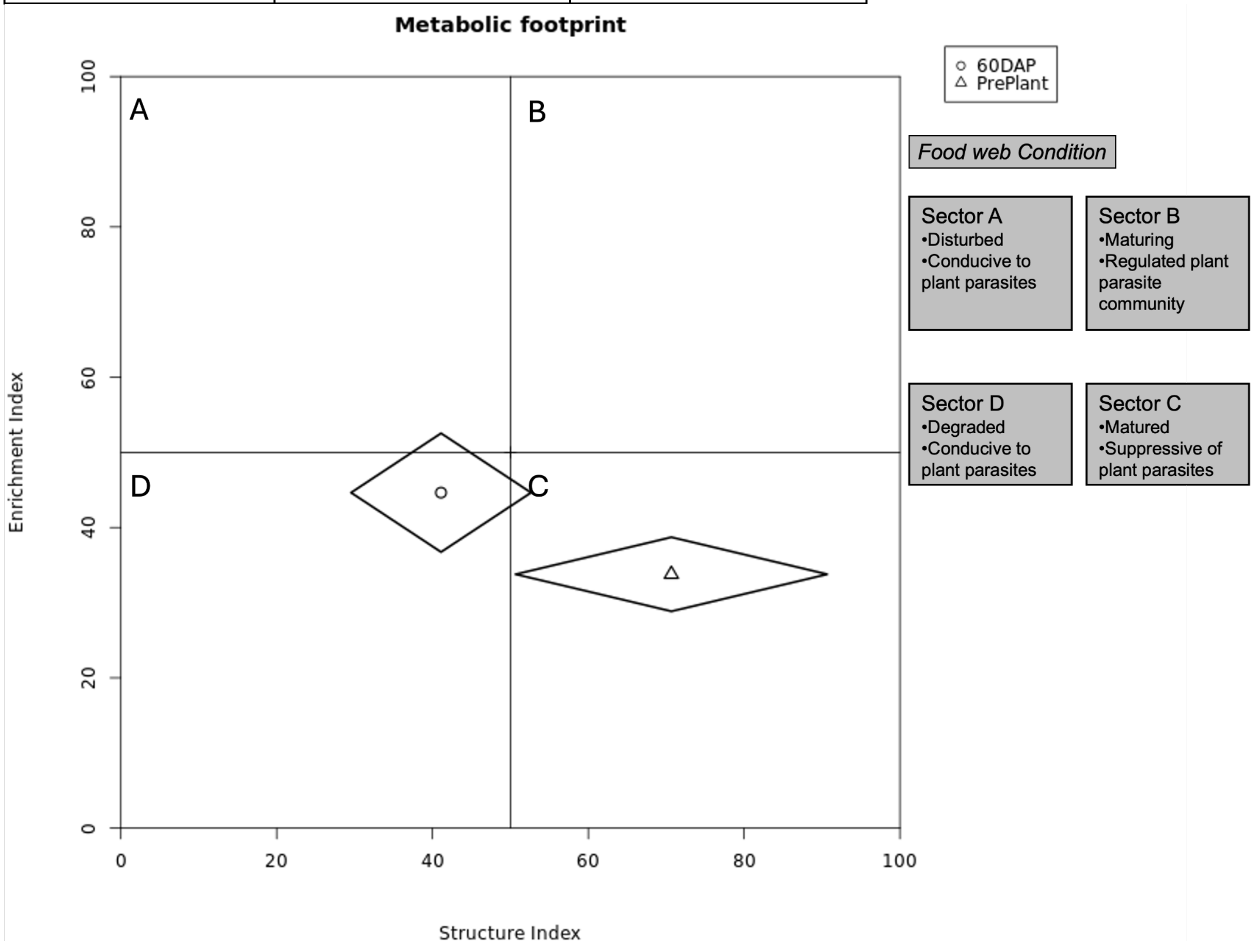
Nematode Identification and Quantification:

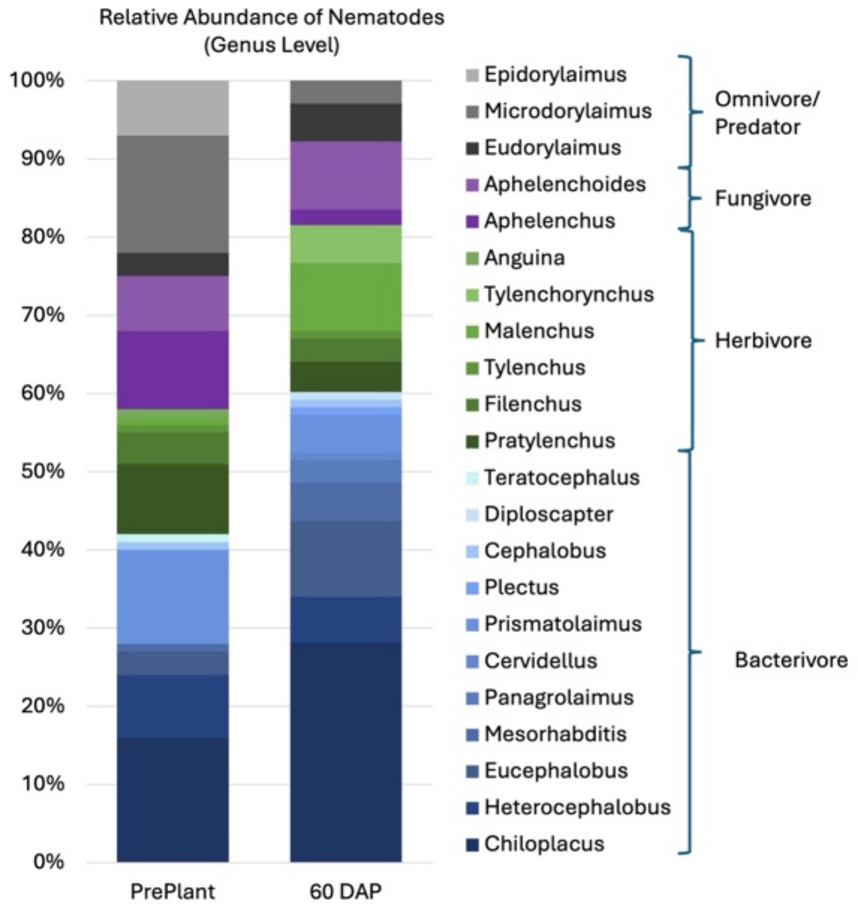
We extracted nematode communities using the Baermann funnel methods and quantified the communities. Identification was done for the first 100 nematodes at the genus-level. Importantly, the absence of plant parasitic nematodes (i.e., *Pratylenchus*) in the soil does not indicate there is no incidence. Plant parasitic nematodes can live inside roots and would not be extracted from standard soil analyses.

Nematode indices are quantified based on colonizer-persister scores for each genus. The maturity index (MI) reflects disturbance with scores close to 1 indicating highly disturbed and closer to 5 indicating stability. The metabolic footprint uses indices to characterize soil health.

Table 7. Nematode abundance and community indices

	Pre-Plant	60 DAP
Abundance	338	697
Maturity Index	2.72 (Moderate)	2.15 (Moderate)





Interpretation:

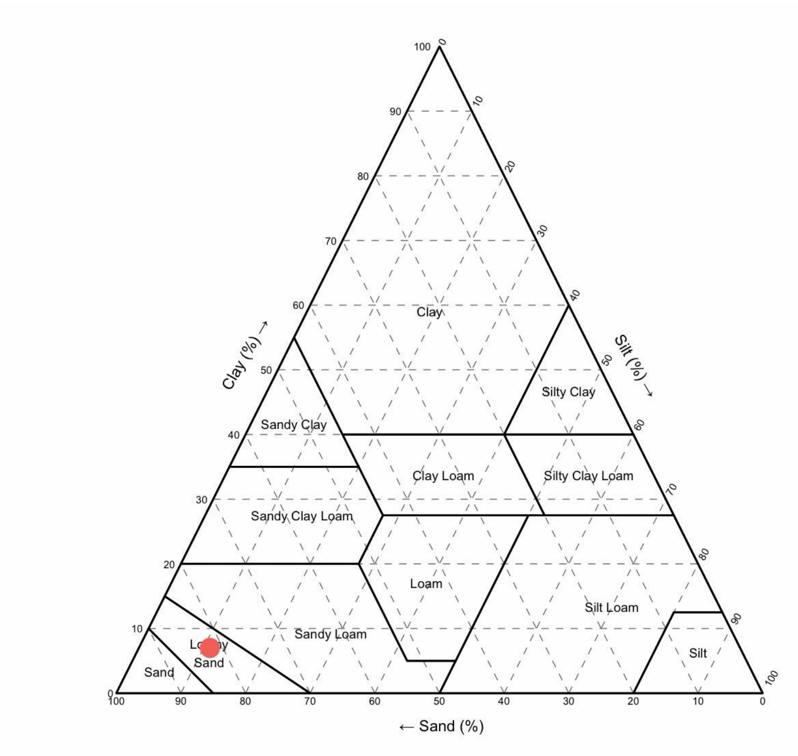
The nematode community indicates some degree of disturbance preplant with disturbance increasing over the growing season. Specifically, the MI remains moderate but decreases over the growing season. The metabolic footprint indicates a mature soil preplant but a degraded soil post plant. Given the high amount of soil disturbance in potato cropping systems, this is not abnormal. The trophic composition of the community is balanced preplant with a high number of predators and omnivores. These nematodes are highly sensitive to physical disturbance and decrease over the growing season. This is likely the cause of the decrease in MI and the results of the post plant metabolic footprint. There are Pratylenchus spp. present at both time points but the numbers decrease over the growing season.

Soil Texture

Soil texture is the percentage of sand, silt and clay. Below is your sample's soil texture from Table 6 mapped out on the USDA Texture Triangle.

Table 6. Texture of your samples.

Texture	
Sand %	82
Silt %	11
Clay %	7
USDA Texture Class	Loamy Sand



Summary:

Overall: The field is a Loamy Sand, which is common for potato fields in Michigan. We recommend considering more management practices to improve carbon and nitrogen for long-term gains in soil health. While the nematode community is relatively good compared to other Michigan potato farms, management strategies should continue to focus on building up the community preplant and recovery of the community after the season.

Assessing the effects of a reservoir tillage practice on water and nutrient management in irrigated Michigan potato fields

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Introduction

Michigan has experienced increasingly erratic precipitation, and rainfall intensity has risen significantly in recent years. Because potato fields are typically tilled, they are especially vulnerable to soil loss through runoff and erosion, particularly on sloped areas. One practice that may help reduce runoff and sediment loss is reservoir tillage. This method creates small depressions between crop rows to capture and retain rainfall or irrigation water. By holding water in place, reservoir tillage can reduce runoff while increasing water and nutrient availability to the crop. Although this practice has been successfully implemented in potato production in other states, its effects on water and nutrient management under Michigan's soil conditions and climate have not been thoroughly evaluated. To address this gap, the team conducted a study in 2024 and continued the research in 2025 to further evaluate treatment effects

Methods

In 2025, the project team (MSU Irrigation Lab and MSU Soil Fertility & Nutrient Management Program) continued to collaborate with Walther Farms to evaluate the effects of reservoir tillage (Dammer Diker) on retaining water and nutrients in a potato field. The yields and quality of potatoes were also observed. This research consists of two treatments: 1) control and 2) reservoir tillage, which utilizes Dammer-Diker. Each treatment was replicated four times. Teros 12 sensors were installed at 9-, 18-, and 24-inch depths to track the soil moisture, temperature, and electrical conductivity on the hill and between the hills. ZL-6 Metergroup dataloggers were used to collect sensor values every 15 minutes. Suction lysimeters were also installed to monitor nitrate levels. Figure 1 shows the demonstration field and the effects of reservoir tillage on water retention. Runoff was also measured using customized flumes and buckets. A metal plate was installed at an upgradient of 50 ft. from the collection point, only to collect runoff and sediments from each treatment area. Installed flumes and collection containers are below. Potato growth was also monitored during the growing season. Potato yield and quality were also monitored.

Figure 1. Geographical location of the study plot with experimental design (left) and applied reservoir tillage (right), during the growing season.

Results and Conclusions

<u>Runoff and soil moisture monitoring</u>

In 2024, reservoir tillage significantly improved field performance relative to the conventional tillage control. Runoff volume (P = 0.045) and sediment loss (P = 0.001) were both reduced, with runoff decreasing by 56% and sediment loss by 67%. These results demonstrate that reservoir tillage effectively retains water and soil within the field. Soil moisture sensor data supported this finding, showing consistently higher soil moisture levels in reservoir tillage plots throughout the growing season. In contrast, the 2025 results did not show statistically significant differences between reservoir tillage and conventional tillage in either runoff volume (P = 0.14) or sediment loss (P = 0.17). This year-to-year variability is likely driven by differences in precipitation. The 2024 season was relatively wet, receiving approximately 16 inches of rainfall during the growing season, which increased the potential for runoff and magnified treatment effects. In comparison, 2025 was considerably drier, with roughly 10 inches of growing-season rainfall, reducing overall runoff and limiting treatment separation. Both test areas in 2024 and 2025 had similar moderate to moderately steep slopes (approximately 5-7%), ensuring comparability across years. Despite differences in runoff and sediment responses, soil moisture data from both years showed a consistent pattern, reservoir tillage maintained higher soil moisture throughout the growing season compared with the control. Figures 2 and 3 illustrate these seasonal soil moisture trends for 2024 and 2025, respectively. In conclusion, these findings indicate that reservoir tillage can substantially reduce runoff and sediment loss under wetter conditions and consistently enhance soil moisture retention across growing seasons.

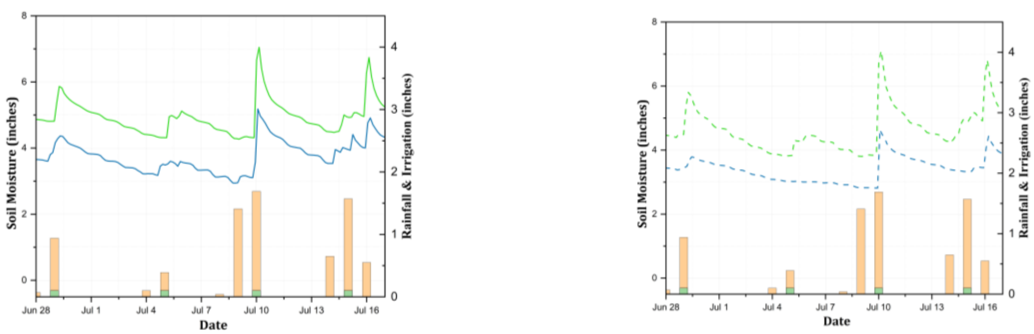

Figure 2. Composite soil moisture comparison at furrow (left), and hill (right) locations for the 2024 growing season.

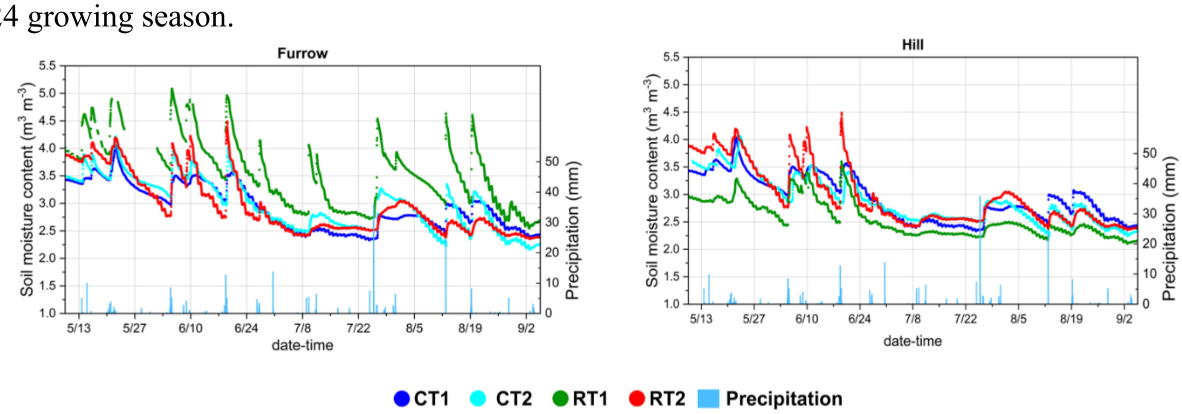

Figure 3. Composite soil moisture comparisons at furrow (left), and hill (right) locations, during the 2025 growing season. #1 Sensors are installed at 6 inch depth. #2 Sensors are installed at 12 inch depth.

Assessment of runoff under varying rainfall intensity

The research team further examined the conditions under which reservoir tillage provides the greatest hydrological benefits using HYDRUS soil water flow modeling. The model was calibrated with field data collected in 2024 and validated with the 2025 dataset.

Runoff simulations indicated a clear nonlinear relationship with rainfall intensity, showing substantial differences between conventional tillage and reservoir tillagein instantaneous runoff flux (Figure 4). Model scenarios indicated that reductions in instantaneous runoff under RT followed an exponential decay pattern as rainfall intensity increased, supported by a strong nonlinear fit ($R^2 = 0.87$). Runoff initiation for both tillage systems occurred at a rainfall intensity of approximately 0.75 in/hour.

The greatest treatment differences, an 80% to 90% reduction in instantaneous runoff under reservoir tillage, occurred at lower rainfall intensities near 0.75 in/hour. At moderate intensities (0.79–1.0 in/hour), reductions ranged from 20% to 60%. However, as rainfall intensity exceeded 1.0 in/hour, RT's relative effectiveness declined. At intensities above 1.1 in/hour, runoff reductions narrowed to only 0% to 10%, indicating limited hydrological advantage during very high-intensity storms. Overall, these results highlight rainfall intensity as a critical determinant of reservoir tillage performance, with the greatest benefits occurring during precipitation events with intensities of 0.75–1 in/hour.

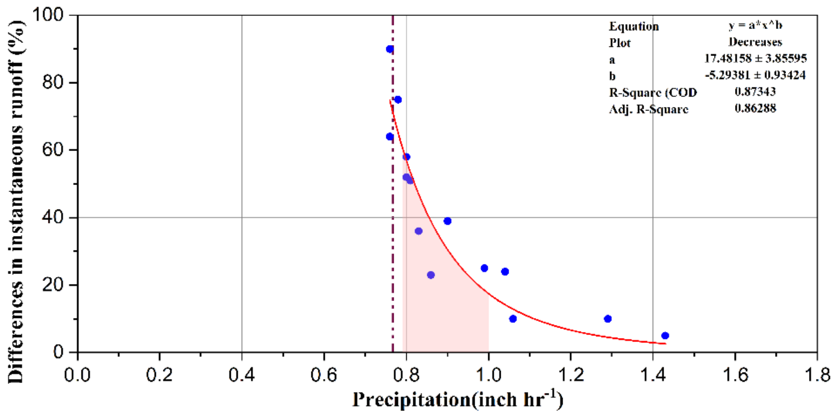

Figure 4. Differences in instantaneous runoff between reservoir tillage and conventional tillage (%), based on instantaneous rainfall (cm hr^{-1}), due to different tillage treatments.

Assessment of runoff under varying daily rainfall amounts

Figure 5 presents simulation results of cumulative runoff under reservoir tillage compared with conventional tillage across a range of daily rainfall amounts. Across all rainfall scenarios, cumulative runoff was consistently lower under reservoir tillage; however, no clear trend was observed with increasing daily precipitation amount, unlike the intensity-based responses shown in Figure 4. In conclusion, reservoir tillage provides meaningful environmental benefits in sloped potato fields, including improved soil moisture retention and a reduced risk of soil loss.

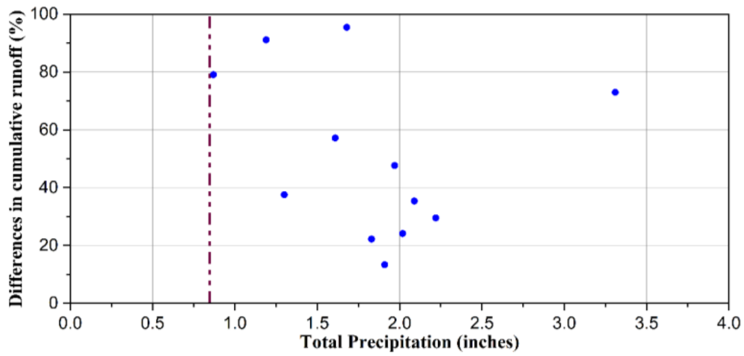

Figure 5. Effect of different tillage treatments on cumulative runoff, based on total daily precipitation (inches).

Yields and quality

Although no statistically significant differences in overall yield were detected between the two treatments in 2025, reservoir tillage produced more consistent yields and reduced variability compared with the control. This greater uniformity is particularly valuable for potato marketability, as stable production supports more predictable grading and supply. Quality assessments, including pink eye, IBS, misshapes, grub damage, hollow heart, seed grade, specific gravity, marketable grade, and oversize, were also conducted, and no significant differences were observed between treatments.

In conclusion, across both the 2024 and 2025 growing seasons, yield variability was consistently lower under reservoir tillage. This stability is likely associated with improved water and nutrient retention, supporting more uniform crop development.

Acknowledgement

We would like to thank the Michigan Potato Industry Commission, Dr. Karl Ritchie, Walther Farms, Lyndon Kelley, Brenden Kelley, Angie Gradiz, Nicolle Ritchie, Greg Rouland, and Caden Wade for their invaluable support in successfully completing the field demonstration.

Project Title: Exploring the Efficacy of 1,4-Dimethylnaphthalene (1,4-DMN) in Enhancing Wound Healing and Reducing Pathogen Spread in Stored Potato Tubers

1. Introduction

Michigan's potato industry is dependent on long-term storage to ensure a continuous supply of raw products for the chipping sector. Tubers are commonly stored for up to 10 months, during which mechanical injuries incurred during harvest, handling, and transportation represent a major vulnerability. These wounds disrupt the native periderm and create entry points for bacterial and fungal pathogens, leading to disease development, increased moisture loss, and reduced marketability (Czajkowski et al. 2011). Even modest levels of postharvest decay can translate into substantial economic losses when scaled across commercial storage facilities (Stefaniak et al 2021).

Successful wound healing in potato tubers depends on rapid suberization and periderm regeneration, processes that restore the protective barrier and limit pathogen ingress. While temperature, humidity, and curing duration are known to influence wound closure, fewer practical tools are available to actively enhance wound-associated defense responses under commercial storage conditions. Consequently, there is a need for storage-compatible interventions that both support wound healing and limit pathogen establishment following mechanical injury.

1,4-Dimethylnaphthalene (1,4-DMN) is a naturally occurring volatile compound in potato tubers and is widely used in commercial storage as a sprout suppressant. Its efficacy in extending dormancy through vapor-phase application is well established, and its use is already integrated into commercial storage facilities. However, beyond sprout suppression, relatively little is known about how commercially relevant concentrations of 1,4-DMN influence wound-associated physiological responses or pathogen development within tuber tissues.

This study was designed to evaluate whether exposure to 1,4-DMN at and around label-equivalent concentrations influences wound healing and disease development in stored potato tubers. The experimental approach focused on standardized wound creation followed by inoculation with representative bacterial and fungal storage pathogens, *Pectobacterium carotovorum* subsp. carotovorum (cause bacterial soft rot) and *Fusarium sambucinum* (cause Fusarium dry rot), respectively. These pathogens were selected to represent contrasting infection strategies, rapid maceration by bacteria versus progressive fungal colonization, allowing assessment of whether 1,4-DMN effects were broadly antimicrobial or pathogen-specific.

To ensure direct relevance to commercial practice, 1,4-DMN was applied in the vapor phase using an inert carrier within sealed containers, with application rates spanning sub-label, label-equivalent (~20 ppm), and modestly high-label concentrations. This concentration range was selected to determine whether antifungal or wound-related effects emerge at doses already used for sprout suppression, or whether higher exposures are required to influence pathogen spread.

Although the initial focus of the project intend to emphasize on enhancement of wound healing and periderm formation, early observations revealed limited effects on bacterial soft rot pathogen but a consistent suppression of *F. sambucinum* spread in 1,4-DMN–treated tubers suggesting the fungistatic role of the compound. Consequently, the study was designed to emphasize pathogen spread dynamics and concentration-dependent responses, while still considering wound healing as a interacting process. By linking storage-relevant application rates with pathogen outcomes, this work provides new insight into the potential expanded role of 1,4-DMN in postharvest disease management and storage loss reduction.

2. Methodology

i. Tuber Material, Wounding, and Pathogen Inoculation

Seed tubers of three commercially relevant potato varieties, Lamoka, Manistee, and Mackinaw were obtained from local Michigan growers. Tubers were visually inspected to exclude defects or pre-existing disease, and randomly assigned to either 1,4-dimethylnaphthalene (1,4-DMN)–treated or untreated control groups. Disease-free were selected and stored at 4 °C in the dark. Subsequently, the tubers were superficially sterilized in 0.5% sodium hypochlorite for 5 min, rinsed thrice with sterile water, and air-dried for one hour in a laminar flow hood before the application of treatment.

To reflect commercial handling conditions, tubers were first wounded prior to chemical treatment. Standardized wounds (15 mm diameter × 2 mm depth) were created on the tuber surface using sterile tools. Immediately following wounding, tubers were inoculated with one of the following treatments:

(a) *Pectobacterium carotovorum* subsp. carotovorum (100 µL of 10^8 CFU mL^{-1} suspension),

(b) *Fusarium sambucinum* (3-mm diameter mycelial plug)

(c) a non-inoculated control.

Following pathogen inoculation, tubers were placed in sealed 5-L TLC glass containers at a fixed mass of approximately 1.5 kg per container. After a 6-h equilibration period, 1,4-DMN was applied at an application rate equivalent to 20 ppm (mg kg^{-1} fresh weight). The compound was dispensed onto $5cm^2$ filter paper within each container, which served as an inert carrier to facilitate volatilization and uniform vapor-phase exposure, consistent with commercial storage application methods. Disease progression was evaluated at 3 and 6 days after inoculation by visual assessment of pathogen spread, lesion development and internal tissue discoloration (at day 6). The evaluation of mycelial growth was performed in two diametrically opposite directions, considering an average of three readings per replicate. At day 6, the tubers were cut along the longitudinal axis around the inoculation sites. Disease development was determined by the rotten area around each wound site as described by de Sousa Santos et al. 2023.

ii. *Microscopy and Wound-Healing Assessment*

To examine anatomical changes associated with wound healing, subsets of tubers were sectioned parallel and perpendicular to the wound surface. Thin sections were stained with toluidine blue and phloroglucinol- HCl to visualize lignin deposition, pectin cross-linking, and suberin formation (UV-visualization). Sections were examined using light and fluorescence microscopy to assess periderm development and structural responses to wounding in treated and untreated tubers.

To fully understand the effect of 1,4 DMN concentration on the pathogen growth and disease progression 1,4-DMN was applied using target concentrations of 0, 5, 10, 15, 20, 25, 30 and 35 ppm. 1, 4 DMN (C10H6(CH3)2; molecular weight: 156.22) was purchased from Millipore Sigma in aqueous form. Tubers were first wounded prior to chemical treatment. Standardized wounds (15 mm diameter × 2 mm depth) were created on the tuber surface using sterile tools. Immediately following wounding, tubers were inoculated with a 3mm-plug of *F. sambucinum*. Following pathogen inoculation, tubers from each variety were placed in sealed 5-L TLC glass containers at a fixed mass of approximately 1.5 kg per container. After a 6-h equilibration period, 1,4-DMN treatments were applied to the containers, and the experiment was repeated twice. The spread of the fungi was repeatedly measured in day 3, 6, 9 and 12. At day 12, the tubers were horizontally cut, and the internal depth of infection was measured as well.

3. Results

Wound inoculation experiments revealed marked differences in the responses of the two tested pathogens to 1,4-DMN treatment. At 6 days after inoculation, the spread of *F. sambucinum* was significantly reduced in tubers treated with 1,4-DMN compared with untreated controls. In treated tubers, fungal growth was typically confined to the immediate wound margin, whereas in untreated tubers the pathogen expanded radially beyond the wound site. When tubers were bisected through the inoculation point, however, no consistent differences in internal infection depth were observed between treated and untreated tubers at this early stage.

In contrast, tubers inoculated with *P. carotovorum* subsp. carotovorum exhibited rapid tissue maceration, water-soaked lesions, and a characteristic foul odor within 6 days after inoculation. Soft rot expansion and tissue breakdown were similar in 1,4-DMN–treated and untreated tubers, indicating that 1,4-DMN did not measurably affect bacterial soft-rot development under the conditions tested. Based on this lack of response, subsequent experiments focused exclusively on *F. sambucinum.*

At 3 days after inoculation, two-way ANOVA revealed a significant main effect of 1,4-DMN treatment on fungal spread, with treated tubers exhibiting reduced growth expansion compared with untreated controls ($F_{1,32} = 29.42$, $P = 5.79 \times 10^{-6}$). Tuber variety had no significant effect on fungal spread ($F_{1,32} = 0.01$, $P = 0.93$), and no significant tuber variety × treatment interaction was detected ($F_{1,32} = 0.13$, $P = 0.72$), indicating that the fungistatic effect of 1,4-DMN was consistent across varieties.

A similar pattern was observed at 6 days after inoculation. The main effect of 1,4-DMN treatment remained significant ($F_{1,32} = 19.94$, $P = 9.31 \times 10^{-5}$), whereas neither tuber variety ($F_{1,32} = 0.04$, $P = 0.85$) nor the tuber x treatment interaction ($F_{1,32} = 1.14$, $P = 0.29$) significantly influenced fungal spread. Together, these results demonstrate that the suppressive effect of 1,4-DMN on *F. sambucinum* growth persisted through day 6 and was independent of tuber variety (Figure 1).

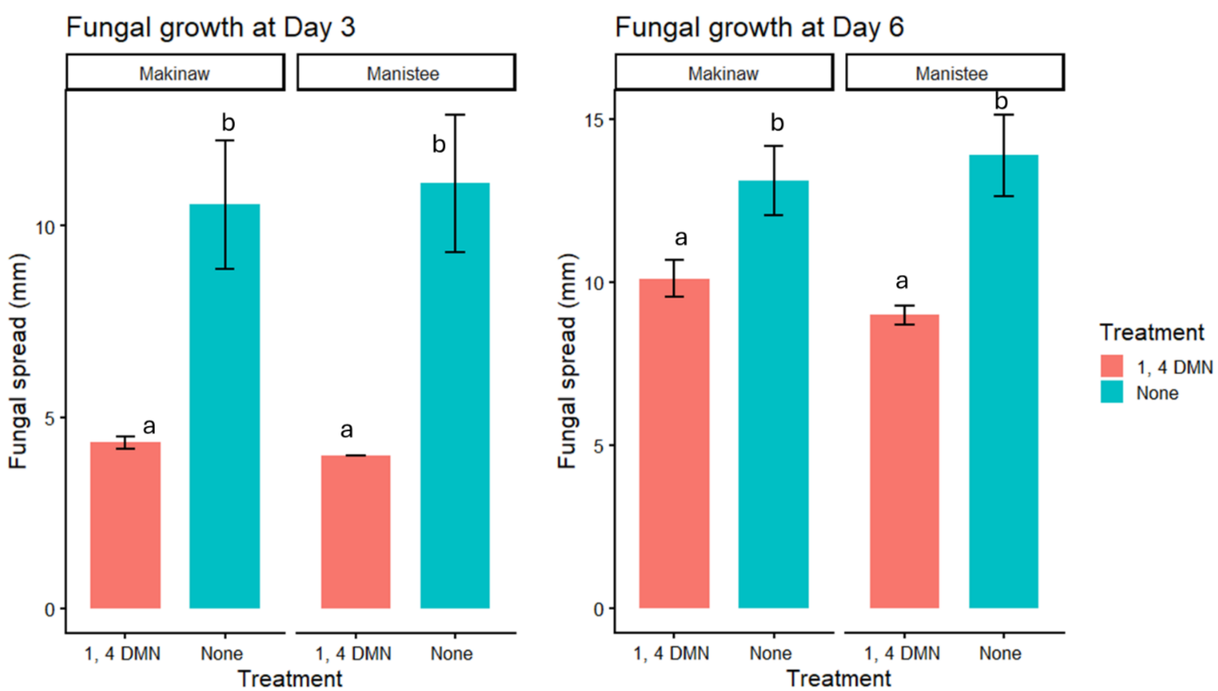

Figure 1. The effect of 20 ppm 1, 4 DMN on the growth of *F. sambucinum* at day 3 and 6, respectively.

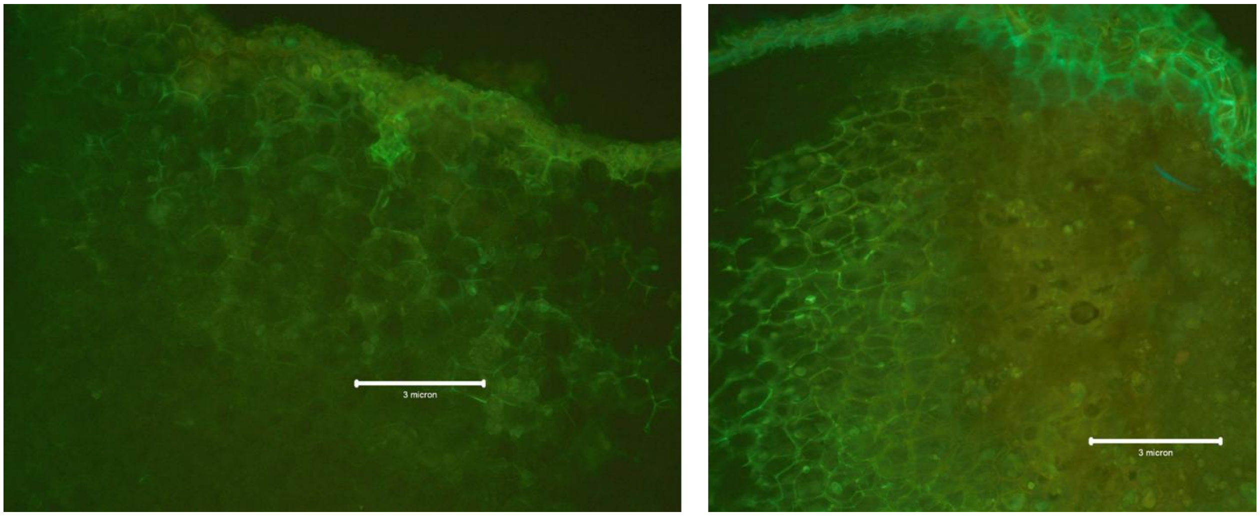

Figure 2. The suberized layer formation after 9-day post wounding in both 1,4 DMN treated and non-treated tuber of Mackinaw. (Preliminary results suggest no significant differences were observed but further detailed study is needed).

Repeated-measures ANOVA confirmed a highly significant effect of 1,4-DMN concentration on fungal spread ($F_{7,40} = 78.52$, $P < 0.001$), a strong effect of time ($F_{3,120} = 1098.30$, $P < 0.001$), and a significant treatment x day interaction ($F_{21,120} = 20.27$, $P < 0.001$). These results indicate that the magnitude of disease suppression by 1,4-DMN varied over time (Figure 2). Lower concentrations temporarily reduced fungal spread at early sampling points, but this effect diminished as storage duration increased. In contrast, the highest concentration (35 ppm) consistently suppressed fungal growth throughout the observation period, particularly in the Manistee variety.

Fungal growth varied strongly with 1,4-DMN concentration. Tubers receiving no treatment or low concentrations (5, 10, and 15 ppm) exhibited extensive mycelial growth by 6 days after inoculation, comparable to untreated controls. In contrast, tubers treated with 20, 25, and 30 ppm showed significantly reduced fungal spread through day 6, indicating that concentrations at or above the commercial label rate delayed pathogen development.

By 9 days after inoculation, sustained suppression of fungal growth was observed only at the highest concentration tested (i.e. 35 ppm). At concentrations ≤30 ppm, fungal growth increased over time, suggesting that *F. sambucinum* was able to overcome the inhibitory effects of 1,4-DMN. At 35 ppm, however, fungal growth was strongly suppressed, with little to no fluffy mycelial development and no complete colonization of the wound surface. In these high-concentration treatments, fungal growth appeared to halt at the wound margin, potentially allowing wound-healing processes to progress and limit further infection. In contrast, untreated and low-concentration treatments exhibited dense mycelial growth that rapidly covered the wounded area, overwhelming host defenses.

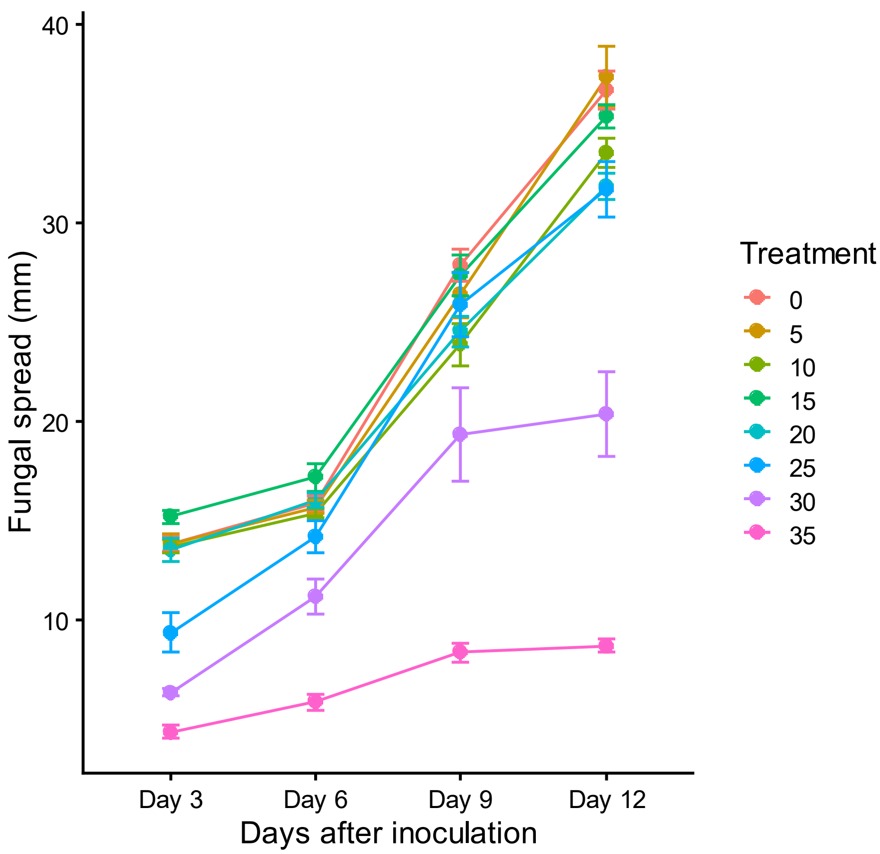

Figure 2: Fungal spread over time under various 1, 4 DMN concentration treatments in Manistee.

Figure 4. Comparison of *Fusarium sambucinum* spread in Manistee potato tubers treated with 1,4-DMN at 15 ppm and 35 ppm, respectively, 9 days after inoculation.

Overall, these results demonstrate that 1,4-DMN significantly reduced the spread of *F. sambucinum* in wounded potato tubers in a concentration- and time-dependent manner, while no measurable suppression was observed for *P. carotovorum* subsp. carotovorum. Concentrations at or above the commercial label rate (> 20 ppm) delayed fungal spread, whereas higher concentrations provided more sustained suppression. Growth inhibition at higher concentrations appeared to create a window period that may allow wound-healing processes to limit pathogen colonization. Although a direct stimulatory effect of 1,4-DMN on wound-healing processes was not evident, the compound may contribute indirectly to wound healing by suppressing pathogen growth. By limiting fungal colonization at the wound site, 1,4-DMN may allow the remaining wounded tissue sufficient time to undergo suberization and new periderm formation, thereby reducing subsequent infection levels.

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2025 MPIC-funded potato research report

Project title: Assessing aphid risk to seed potato in Michigan

PI: Zsofia Szendrei

Research Objectives

Objective 1) Develop and share an aphid sampling protocol with seed potato growers, process sampling data for analysis.

Objective 2) Analyze and share aphid results with stakeholders.

Results:

Obj. 1)

In the winter of 2025, we collaborated with Damen Curzer, the Executive Director of the Michigan Seed Potato Association to reach out to seed potato growers and gauge their interest in participating in the pilot aphid monitoring program. We also developed a sampling protocol that explained to growers how to use and preserve the yellow sticky card traps, as well as an Aphid Monitoring app that growers used to submit photos of cards and view weekly total aphid means over time. We shared the program at the Winter Seed Potato Growers Meeting on February 19th, and 14 growers were willing to sample in a total of 36 seed potato fields. We then held a webinar on April 28th on the aphid sampling protocol and how to use the Aphid Monitoring app, and sampling began once the potato plants began to emerge from the soil.

We processed the submitted aphid photo data for 12 weeks, from the beginning of June to the end of August 2025, counting the total number of aphids per card and publishing the total aphid abundance across all submitted sites in the app each week. This showed that aphid abundance was stable throughout June and July but spiked in August before decreasing again. These trends correlate with aphid abundance trends in the rest of the region and with the forecasted Potato Virus Y risk for the UP in the decision support model available through the University of Wisconsin's Vegetable and Disease Incidence Forecasting Network (VDIFN) (Fig. 1). However, aphid abundance did not increase in our sampling data until week 9, which suggests that aphid conditions in the

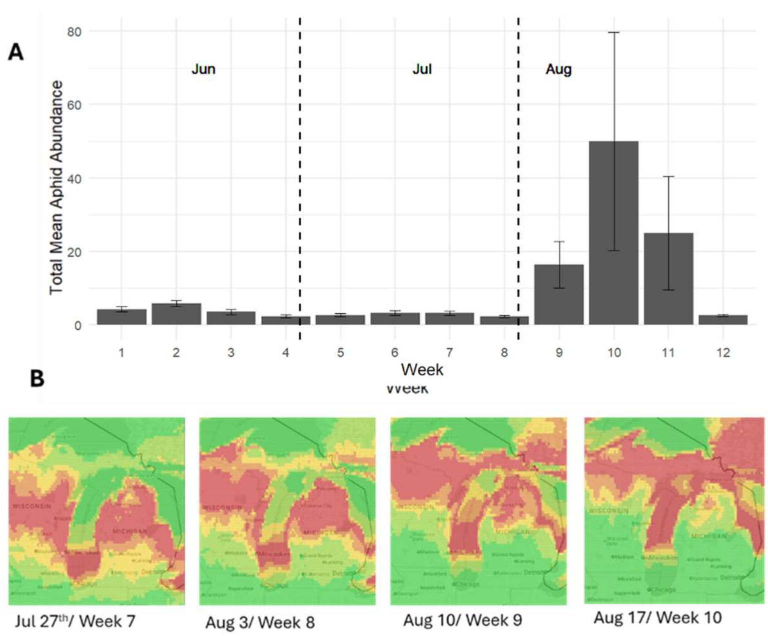

Figure 1. A) Total mean aphid abundance with standard error bars. B) PVY risk forecasts from the VDIFN website when aphid abundance is highest. Red is highest risk, and green is lowest.

UP lag behind the risk forecast model. In addition to counting aphids and providing weekly mean abundance, we also collected the cards from growers once sampling and harvest ended and attempted to identify each aphid to species, using a microscope and aphid key. We were able to identify approximately 75% of all aphids to the genus level.

Obj. 2)

We have used this data to estimate the risk of Potato Virus Y transmission. The PVY risk index is estimated by taking the total weekly abundance of each vector species and multiplying by its transmission efficiency (as available in scientific literature). This method is also used to develop the VDIFN risk forecasts. By completing this for all vector species found in each week, the sum risk index shows how PVY risk changes across the growing season. We found that while aphid abundance corresponds to the forecasted PVY risk, the PVY risk index did not because many of the aphids driving the peak abundance were not PVY vectors (Fig. 2). Furthermore, we found that PVY risk index was higher in the early season, when there were fewer aphids total, but a higher proportion of vector species.

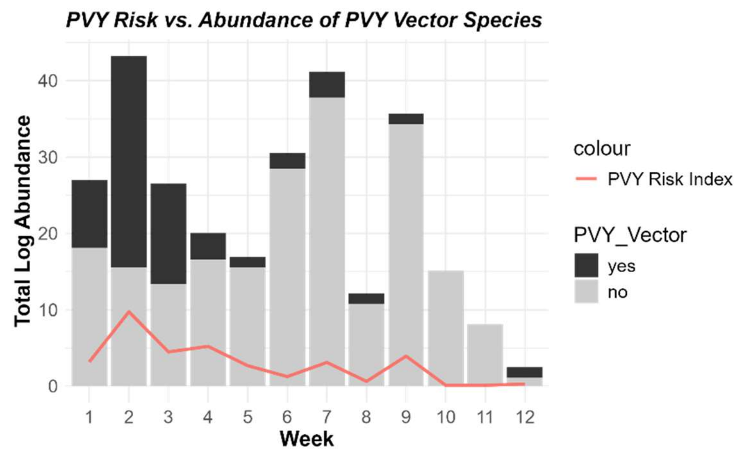

Figure 2. Aphid abundance from yellow sticky traps in 2025 and identified to species. Total weekly log abundance of PVY vector species is black, and non-vectors are gray.

The preliminary results of this analysis were shared with seed potato growers at their Summer Seed Potato Growers Meeting on August 13th, and a more complete overview of the results will be shared at the Winter Potato Conference on January 28th. I also distributed information about aphid management to stakeholders at the MSU Potato Field Day on August 7th and the UP Potato Field Day on August 28th.

Investigating Integrated Weed Management Strategies for Potatoes-2025 MPIC Research Report

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Michigan potato production is threatened, on an annual basis, by many pests. These pests result in six to ten percent crop loss and in millions of dollars of lost sales. Colorado potato beetle (CPB) is the most important defoliator of potatoes world-wide. CPB has developed resistance to all known classes of insecticides used to control it in commercial production. Volunteer potatoes further exacerbate CPB damage. Volunteer potatoes are an optimal food source for CPB which then move into neighboring potato fields and defoliate. Historically harsh winter temperatures kill tubers that remain in the field after harvest. Although, in regions where winters are mild and soil temperatures are not cold enough to kill tubers left in the field, tubers can survive, overwinter and become a serious weed problem. Not only do volunteer potatoes compete with crops and reduce yield, but they also harbor insects, diseases, and nematodes that can infest neighboring or future potato crops. Therefore, the objective of these studies was the identification, development, and implementation of integrated tools to control both volunteer potatoes and CPB which is essential to maintaining sustainable potato production in Michigan.

Objective 1*: Conduct field studies to investigate the impacts of herbicide and application of potato sprout inhibitors for volunteer potato management.* Variability in volunteer emergence, large energy reserves, and daughter tuber production reduces the reliability of conventional herbicides for effective control. Maleic hydrazide (MH), a plant growth regulator historically used to inhibit sprouting in long-term potato storage, may offer potential as a management tool by preventing daughter tuber formation and thereby reducing volunteer pressure in subsequent seasons. This study was conducted in 2025 at East Lansing, MI, using a randomized complete block design with four replications. To simulate volunteers, potatoes were spread at a density of 3.25 tubers m^2 and tilled in with a disk. Treatments were arranged factorially and included four application timings (24, 31, 38, and 45 days after planting-DAP) and three herbicide treatments: mesotrione alone (MESO), mesotrione plus maleic hydrazide (MESO + MH), and a non-treated control (NTC). Data collected included visual foliar injury ratings (14, 21, and 28 days after application-DAA). Additionally, five plants per plot were excavated to assess daughter tuber production, including tuber number and total tuber weight per plant. All data were analyzed using linear mixed-effects models in R and treatment means were separated using Tukey's HSD. Visual foliar injury ratings were significantly affected by application timing ($p<0.0001$) across all timepoints, with the greatest control observed at the earliest application timing and the least control at the latest timing. Daughter tuber number was significantly affected by application timing ($p=0.043$), with the 38 DAP timing producing 22% more tubers than the 31 DAP timing. Daughter tuber weight per plant was significantly affected by treatment ($p<0.0001$), with non-treated controls producing 47% greater tuber weight than MESO and MESO + MH treatments. Resulting daughter tubers are currently in storage to understand the impacts of maleic hydrazide on tuber viability. This study will be conducted again in 2026.

Objective 2*: Investigate volunteer potato control in rotational crops (soybean, sugarbeet, winter wheat, dry bean, and alfalfa).* This study investigated control of volunteer potatoes in rotational crops outside of corn. With the growing diversity of potato cropping systems there is a need to investigate control of volunteer potatoes in diverse rotational crops. This study was conducted at the Montcalm Research Center. Potatoes were spread and incorporated to simulate a dense population of volunteers. Herbicide applications (Table 1) were applied to 8-12 in volunteers. Overall, increasing rates of Roundup (glyphosate) resulted in sufficient daughter tuber control (Figure 1. 1-3). For treatments relying on 2,4-D (Enlist) the addition of glyphosate is needed to control daughter tubers (Figure 1. 4-6). Raptor and Basagran application regardless of rate were not effective (Figure 1. 7-8). Clarity applied at the rate used in winter wheat was not effective (Figure 1. 9), however Huskie application reduced daughter tuber production (Figure 1, 10). Stinger HL application was not highly effective (Figure 1, 11).

Table 1. Herbicide treatments utilized in objective 2.

Treatment No.	Treatment Name	Rate
1	Roundup PowerMax3	20 fl oz/a
1	AMS	8.5 lb/100 gal
2	Roundup PowerMax3	30 fl oz/a
2	AMS	8.5 lb/100 gal
3	Roundup PowerMax3	40 fl oz/a
3	AMS	8.5 lb/100 gal
4	Enlist Duo	4.75 pt/a
5	Enlist	2 pt/a
5	Roundup PowerMax3	30 fl oz/a
5	AMS	8.5 lb/100 gal
6	Enlist	2 pt/a
7	Raptor	4 fl oz/a
7	Basagran	12.8 fl oz/a
7	COC	1% v/v
7	AMS	8.5 lb/100 gal
8	Raptor	4 fl oz/a
8	Basagran	6.4 fl oz/a
8	COC	1% v/v
8	AMS	8.5 lb/100 gal
9	Clarity	4 fl oz/a
10	Huskie	15 fl oz/a
10	NIS	0.25% v/v
10	AMS	8.5 lb/100 gal
11	Stinger HL	0.2 pt/a

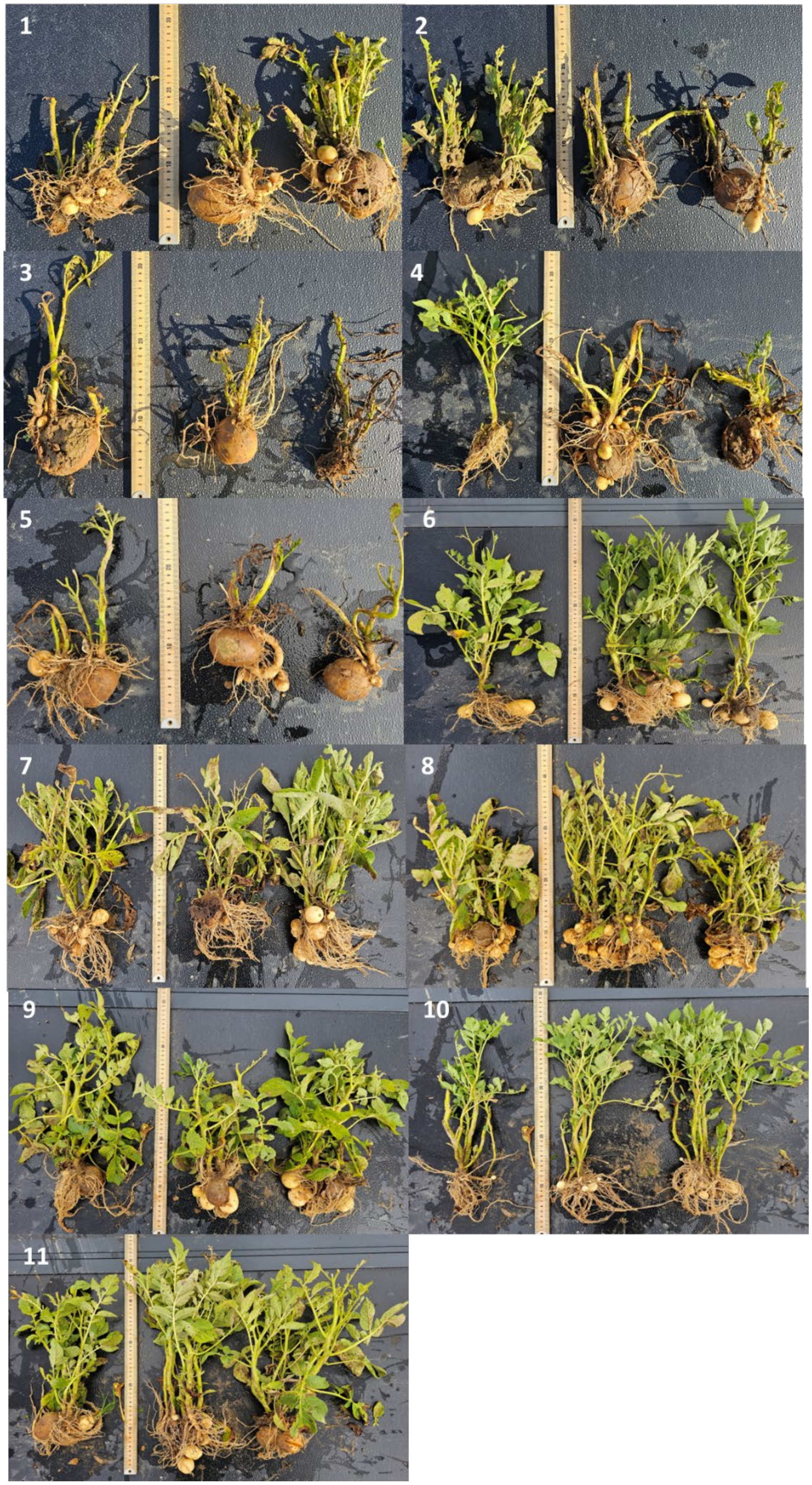

Figure 1. Volunteer potato control 28 days after herbicide application. Numbers refer to treatments outlined in Table 1.