Update On The Determination Of Rust (*Puccinia helianthi*) Virulence and Associated Rust Projects

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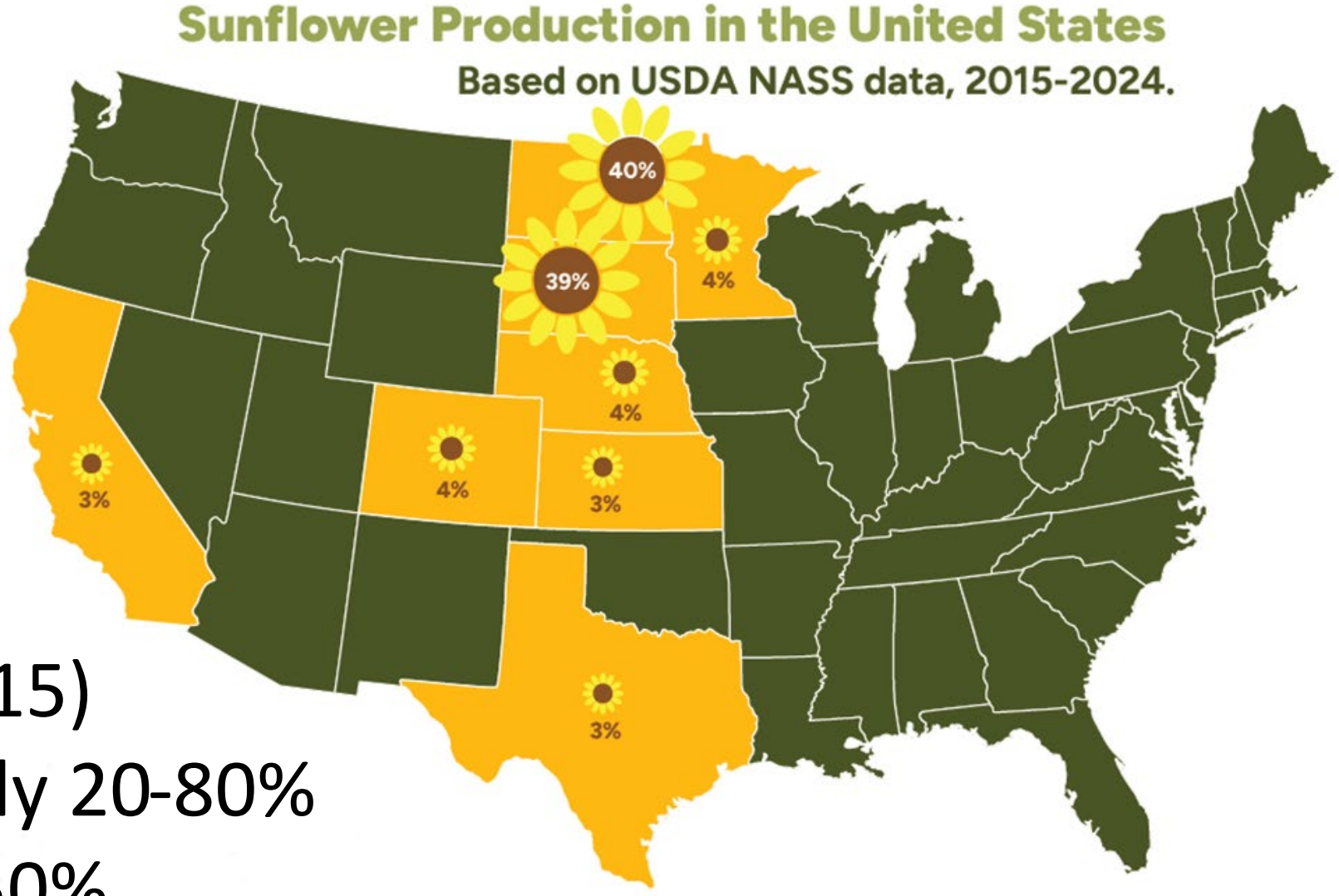
Project Update Outline

- Prevalence = Does rust occur in a field? (Yes/Fields Surveyed)
- Virulence = Can the pathogen overcome a resistance gene?
- Additional/Future objectives

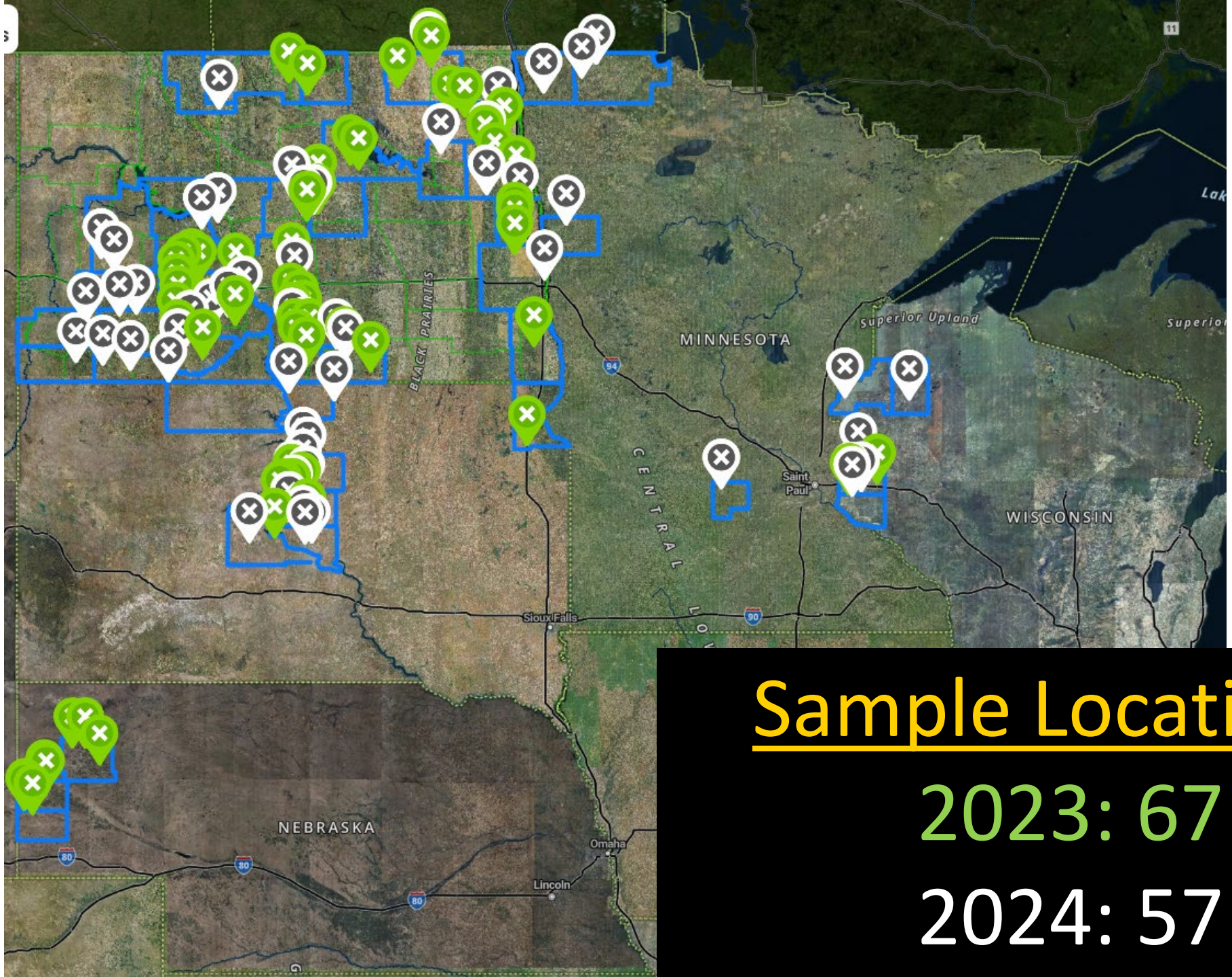
Introduction: Sunflower

- 1.3-2.0 million acres planted annually
- Rust is a top 5 sunflower disease.
- Prevalence (2002-2015)
  - Range approximately 20-80%
  - Mean of about 40-50%



(Courtesy of North Central Integrated Pest Management Center)

(Photos: Zachary Ittel)



Sample Locations:

2023: 67

2024: 57

(ONX)

Prevalence: Results

	2023			
North Dakota	41/43			
South Dakota	8/8			
Wisconsin	6/6			
Nebraska	10/10			
Minnesota	…			
Totals	65/67			

Prevalence: Results

	2023	2024		
North Dakota	41/43	31/31		
South Dakota	8/8	15/15		
Wisconsin	6/6	6/6		
Nebraska	10/10	…		
Minnesota	…	5/5		
Totals	65/67	57/57		

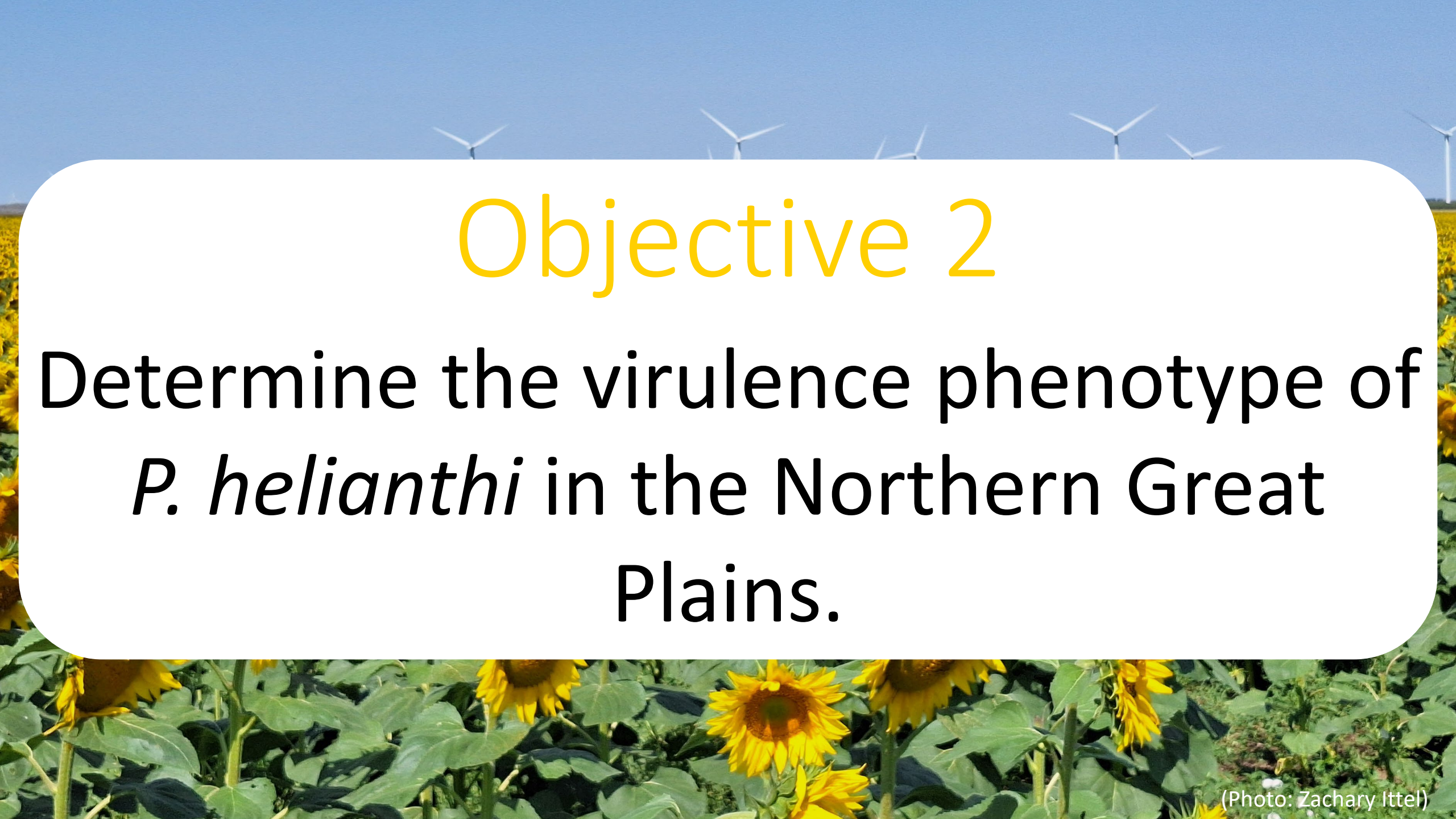
Rust Prevalence 2023-2024

122/124 Fields

>98%

Objective 2

Determine the virulence phenotype of *P. helianthi* in the Northern Great Plains.



(Photo: Zachary Ittel)

Introduction: Pathogen Virulence

- New races can overcome genetic resistance
- Management:
  - Genetic Resistance
  - Fungicides
  - Removal of volunteer plants

(Berghuis et al. 2021; Friskop et al. 2015; Gulya and Masirevic 1996)

(Photos: Zachary Ittel)

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(Berghuis et al. 2021; Friskop et al. 2015; Gulya and Masirevic 1996)

(Photos: Zachary Ittel)

Virulence: Background

R genes

Hybrids

Reoccurring Rust Life Cycles

New races

~~R genes~~

A race survey informs breeders

(Photo: Zachary Ittel)

Virulence: Background

P. helianthi Virulence in 2011-2012

- 238 single pustule isolates
  - 29 races
  - Wide diversity of virulence
- States: NE, ND, SD, CA, IA, MN, TX, and MB.
- NE, ND, and MB each had rust that could overcome all known R genes

National Sunflower Association

(Friskop et al. 2015)

P. helianthi Virulence in California during 2017-2018

Production fields:

- 2017 – 6 races (11 SPI)
- 2018 – 8 races (13 SPI)

Wild sunflower:

- 2017 – 6 races (11 SPI)
- 2018 – 16 races (20 SPI)

- CA had rust that could overcome all known R genes
- Wide diversity of virulence

(Berghuis et al. 2021)

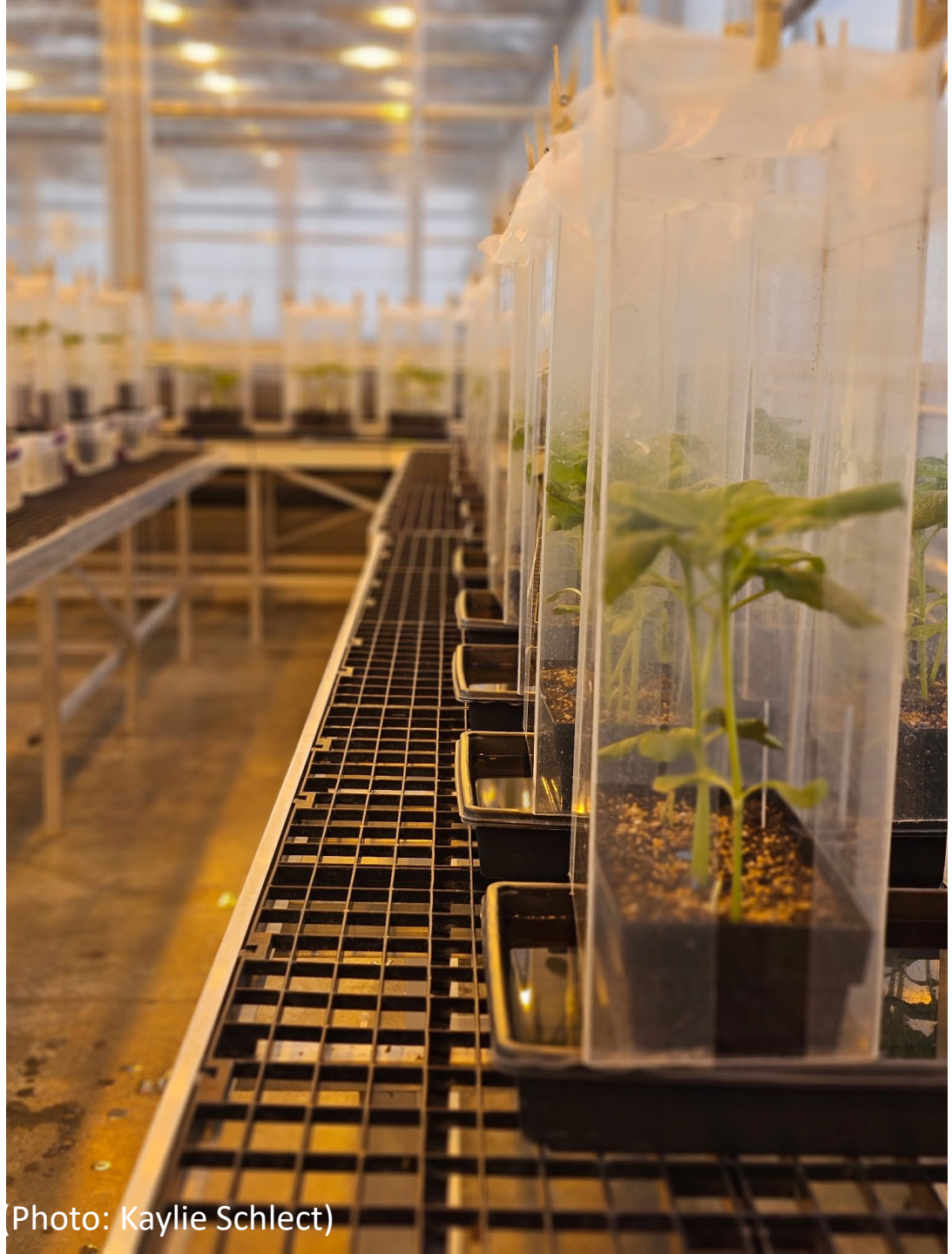
National Sunflower Association

Virulence: Methods (Pathogen Recovery)

(Photo: Zachary Ittel)

(Photo: Denis Colombo)


(Photo: Zachary Ittel)



(Photo: Kaylie Schlect)

(Photo: Zachary Ittel)

(Photo: Daniel Gill)

Prevalence: Results

	2023	2024	Bulk Isolates	
North Dakota	41/43	31/31	123	
South Dakota	8/8	15/15	45	
Wisconsin	6/6	6/6	33	
Nebraska	10/10	…	30	
Minnesota	…	5/5	3	
Totals	65/67	57/57	234	

Prevalence: Results

	2023	2024	Bulk Isolates	SPI's
North Dakota	41/43	31/31	123	30
South Dakota	8/8	15/15	45	18
Wisconsin	6/6	6/6	33	6
Nebraska	10/10	…	30	0
Minnesota	…	5/5	3	2
Totals	65/67	57/57	234	56


Determining
Virulence Phenotype
(Race)
(Photo: Zachary Ittel)

Infection Type (IT)

(Photos: Dr. Brandt Berghuis)

0

1 (<0.2mm)

2 (0.2-0.4mm)

3 (0.4-0.6mm)

4 (0.6-0.8mm)

5 (0.8mm)

Universal Differential Set

Triplet	Differential	Resistance Gene	Scoring Value
One	7350	…	1
	MC90	R_1	2
	MC29	R_2+R_{10}	4
Two	P386	R_{4e}	1
	HA-R1	R_{4a}	2
	HA-R2	R_5	4
Three	HA-R3	R_{4b}	1
	HA-R4	R_{4c}	2
	HA-R5	R_{4d}	4

(Friskop et al. 2015; Gulya and Masirevic 1996)

Triplet	Differential	Resistance Gene	Scoring Value	Code
One	7350	…	1	
	MC90	R_1	2	
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Triplet	Differential	Resistance Gene	Scoring Value	Code
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	MC29	R_2+R_{10}	4	
Two	P386	R_{4e}	1	4
	HA-R1	R_{4a}	2	
	HA-R2	R_5	4	
Three	HA-R3	R_{4b}	1	7
	HA-R4	R_{4c}	2	
	HA-R5	R_{4d}	4	

Race Name = 347

Universal Differential Set

Triplet	Differential	Resistance Gene	Scoring Value
One	7350	…	1
	MC90	R_1	2
	MC29	R_2 – R_{10}	4
Two	P386	R_{4c}	1
	HA-R1	R_{4a}	2
	HA-R2	R_5	4
Thr	HA-R3	R_{4b}	1
	HA-R4	R_{4c}	2
	HA-R5	R_{4d}	4

(Friskop et al. 2015; Gulya and Masirevic 1996)

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	HA-R1	R_{4a}	2	
	HA-R2	R_5	4	
Three	HA-R3	R_{4b}	1	
	HA-R4	R_{4c}	2	
	HA-R5	R_{4d}	4	
Four	?	?	?	?
	?	?	?	
	?	?	?	

Differential Additions

Differential Name	Pedigree	Gene	Year Released
HAR-9	Selection of Rf ANN 1742	R_{11}	2013
RHA 464	Selection of PI 413047	R_{12}	2013
HAR-6	(R702CLPlus/HAR6-1)F2	R_{13a}	2013
HAR-8	Selection of PI 432512	R_{15}	2018
HAR-18	Selection of South Africa line KP193	R_{17}	2020
HAR-19	Selection of South Africa line KP193	R_{18}	2020

(Bulos et al. 2013; Gong et al. 2013; Ma et al. 2018; Meyer et al. 2021; Qi et al. 2014; Qi et al. 2021)

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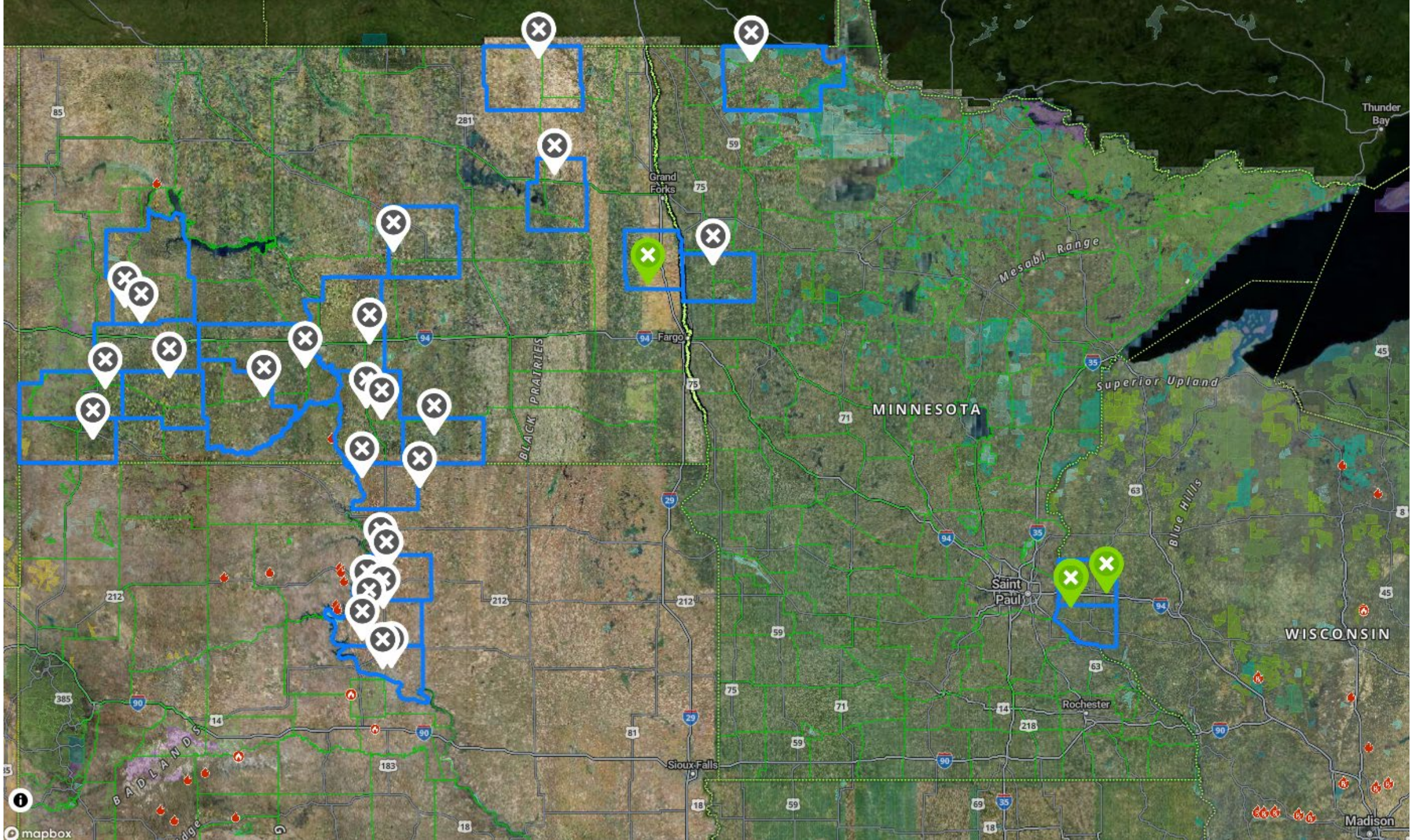
	RHA 464	R_{12}	2
	HAR-6	R_{13a}	4
Five	HAR-8	R_{15}	1
	HAR-18	R_{17}	2
	HAR-19	R_{18}	4


Thunder Bay
Grand Forks
Fargo
Mesabi Range
BLACK PRAIRIES
MINNESOTA
Superior Upland
Blue Hills
Saint Paul
WISCONSIN
Rochester
Sioux Falls
BADLANDS
Madison
mapbox

Differential	Resistance Gene	Virulent/Screened	% Virulent
7350	…		
MC90	R_1		
MC29	R_2+R_{10}		
P386	R_{4e}		
HA-R1	R_{4a}		
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HA-R4	R_{4c}		
HA-R5	R_{4d}		
HAR-9	R_{11}		
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HAR-6	R_{13a}		
HAR-8	R_{15}		
HAR-18	R_{17}		
HAR-19	R_{18}		

Differential	Resistance Gene	Virulent/Screened	% Virulent
7350	…	33 / 33	
MC90	R_1	33 / 33	
MC29	R_2+R_{10}	2 / 28	
P386	R_{4e}	16 / 31	
HA-R1	R_{4a}	22 / 33	
HA-R2	R_5	9 / 29	
HA-R3	R_{4b}	3 / 27	
HA-R4	R_{4c}	7 / 23	
HA-R5	R_{4d}	31 / 33	
HAR-9	R_{11}	4 / 14	
RHA 464	R_{12}	5 / 25	
HAR-6	R_{13a}	0 / 32	
HAR-8	R_{15}	1 / 33	
HAR-18	R_{17}	3 / 32	
HAR-19	R_{18}	14 / 32	

Differential	Resistance Gene	Virulent/Screened	% Virulent
7350	…	33 / 33	100%
MC90	R_1	33 / 33	100%
MC29	R_2+R_{10}	2 / 28	7%
P386	R_{4e}	16 / 31	52%
HA-R1	R_{4a}	22 / 33	67%
HA-R2	R_5	9 / 29	31%
HA-R3	R_{4b}	3 / 27	11%
HA-R4	R_{4c}	7 / 23	30%
HA-R5	R_{4d}	31 / 33	94%
HAR-9	R_{11}	4 / 14	29%
RHA 464	R_{12}	5 / 25	20%
HAR-6	R_{13a}	0 / 32	0%
HAR-8	R_{15}	1 / 33	3%
HAR-18	R_{17}	3 / 32	9%
HAR-19	R_{18}	14 / 32	44%

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Race Comparison

31406

32400

32406

32424

33400

33440

33440

33700

37400

37410

37737

74010

Race Comparison

31406

32400

32406

32424

33400

33440

33440

33700

37400

37410

37737

74010

Race Comparison

31406

32400

32406

32424

33400

33440

33440

33700

37400

37410

37737

74010

Differential	Resistance Gene	2011-2012	2017-2018	2023-2024
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MC90	R_1	100%	92%	100%
MC29	R_2+R_{10}	16%	28%	7%
P386	R_{4e}	26%	78%	52%
HA-R1	R_{4a}	40%	84%	67%
HA-R2	R_5	21%	2%	31%
HA-R3	R_{4b}	4%	42%	11%
HA-R4	R_{4c}	33%	72%	30%
HA-R5	R_{4d}	98%	74%	94%
HAR-9	R_{11}	-	-	29%
RHA 464	R_{12}	-	-	20%
HAR-6	R_{13a}	-	-	0%
HAR-8	R_{15}	-	-	3%
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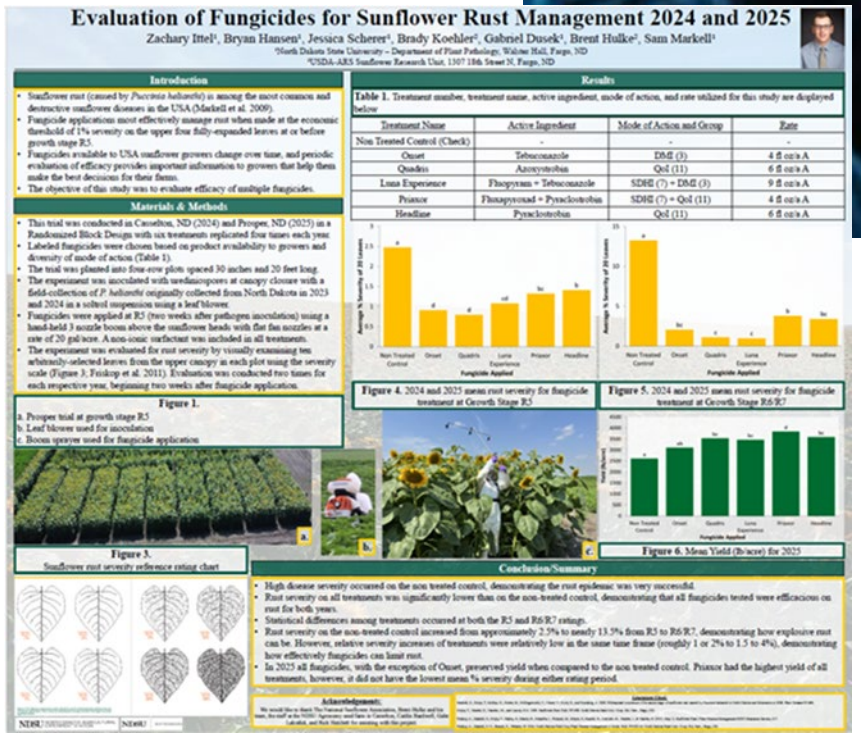
HAR-8	R_{15}	-	-	3%
HAR-18	R_{17}	-	-	9%
HAR-19	R_{18}	-	-	44%

Race Comparison

2011-2012	2017-2018	2023-2024*
238 isolates 29 races Virulence on 9/9 differentials Most common: 300 & 304	55 isolates 22 races Virulence on 9/9 differentials Most common: 336	31 isolates Virulence on 14/15 differentials Most common: 33400

Additional/Future Objectives

- *Puccinia helianthi* population genetic analysis



Evaluation of Fungicides for Sunflower Rust Management 2024 and 2025

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[1]North Dakota State University – Department of Plant Pathology, Walster Hall, Fargo, ND

[2]USDA-ARS Sunflower Research Unit, 1307 18th Street N, Fargo, ND

Introduction

- Sunflower rust (caused by *Puccinia helianthi*) is among the most common and destructive sunflower diseases in the USA (Markell et al. 2009).
- Fungicide applications most effectively manage rust when made at the economic threshold of 1% severity on the upper four fully-expanded leaves at or before growth stage R5.
- Fungicides available to USA sunflower growers change over time, and periodic evaluation of efficacy provides important information to growers that help them make the best decisions for their farms.
- The objective of this study was to evaluate efficacy of multiple fungicides.

Materials & Methods

- This trial was conducted in Casselton, ND (2024) and Prosper, ND (2025) in a Randomized Block Design with six treatments replicated four times each year.
- Labeled fungicides were chosen based on product availability to growers and diversity of mode of action (Table 1).
- The trial was planted into four-row plots spaced 30 inches and 20 feet long.
- The experiment was inoculated with urediniospores at canopy closure with a field-collection of *P. helianthi* originally collected from North Dakota in 2023 and 2024 in a solitrol suspension using a leaf blower.
- Fungicides were applied at R3 (two weeks after pathogen inoculation) using a hand-held 3 nozzle boom above the sunflower heads with flat fan nozzles at a rate of 20 gal/acre. A non-ionic surfactant was included in all treatments.
- The experiment was evaluated for rust severity by visually examining ten arbitrarily-selected leaves from the upper canopy in each plot using the severity scale (Figure 3; Freikop et al. 2011). Evaluation was conducted two times for each respective year, beginning two weeks after fungicide application.

Figure 1.

a. Prosper trial at growth stage R5
b. Leaf blower used for inoculation
c. Boom sprayer used for fungicide application

Figure 3.
Sunflower rust severity reference rating chart

Results

Table 1. Treatment number, treatment name, active ingredient, mode of action, and rate utilized for this study are displayed below

Treatment Number	Treatment Name	Active Ingredient	Mode of Action and Group	Rate
1	Non Treated Control (Check)	-	-	-
2	Onset	Tebuconazole	DMI (3)	4 fl oz/a A
3	Quadris	Azoxystrobin	QoI (11)	6 fl oz/a A
4	Luna Experience	Fluopyram + Tebuconazole	SDHI (7) + DMI (3)	9 fl oz/a A
5	Priaxor	Fluxapyroxad + Pyraclostrobin	SDHI (7) + QoI (11)	4 fl oz/a A
6	Headline	Pyraclostrobin	QoI (11)	6 fl oz/a A

Figure 4. 2024 and 2025 mean rust severity for fungicide treatment at Growth Stage R5

Figure 5. 2024 and 2025 mean rust severity for fungicide treatment at Growth Stage R6/R7

Figure 6. Mean Yield (lb/acre) for 2025

Conclusion/Summary

- High disease severity occurred on the non treated control, demonstrating the rust epidemic was very successful.
- Rust severity on all treatments was significantly lower than on the non-treated control, demonstrating that all fungicides tested were efficacious on rust for both years.
- Statistical differences among treatments occurred at both the R5 and R6/R7 ratings.
- Rust severity on the non-treated control increased from approximately 2.5% to nearly 13.5% from R5 to R6/R7, demonstrating how explosive rust can be. However, relative severity increases of treatments were relatively low in the same time frame (roughly 1 or 2% to 1.5 to 4%), demonstrating how effectively fungicides can limit rust.
- In 2025 all fungicides, with the exception of Onset, preserved yield when compared to the non treated control. Priaxor had the highest yield of all treatments, however, it did not have the lowest mean % severity during either rating period.

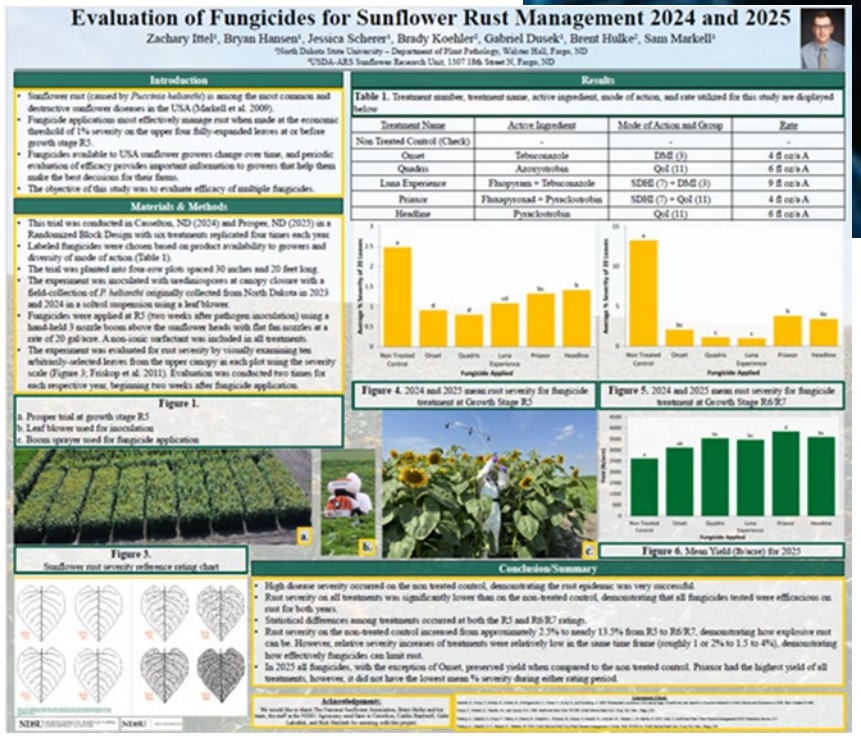
Acknowledgements:

Literature Cited:

Additional/Future Objectives

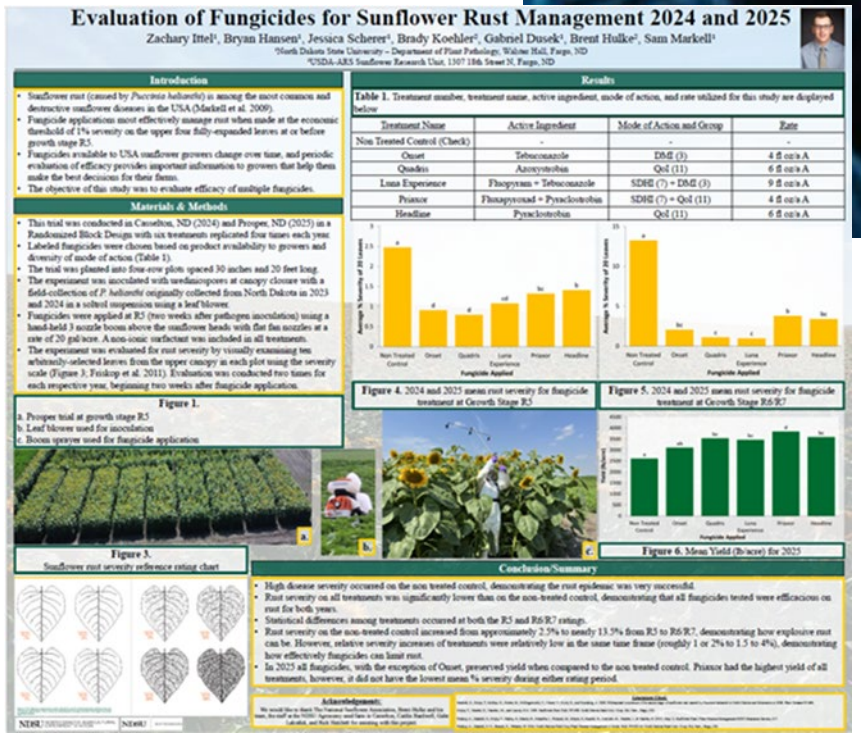
- *Puccinia helianthi* population genetic analysis

- Whole Genome Pathogen Sequencing



Additional/Future Objectives

- *Puccinia helianthi* population genetic analysis
- Whole Genome Pathogen Sequencing
- SAM pop experiment



Evaluation of Fungicides for Sunflower Rust Management 2024 and 2025

Zachary Ittel[1], Bryan Hansen[1], Jessaca Scherer[1], Brady Koehler[2], Gabriel Dusek[1], Brent Hulke[2], Sam Markell[1]

[1]North Dakota State University – Department of Plant Pathology, Walster Hall, Fargo, ND

[2]USDA-ARS Sunflower Research Unit, 1307 18th Street N, Fargo, ND

Introduction

- Sunflower rust (caused by *Puccinia helianthi*) is among the most common and destructive sunflower diseases in the USA (Markell et al. 2009).
- Fungicide applications most effectively manage rust when made at the economic threshold of 1% severity on the upper four fully-expanded leaves at or before growth stage R5.
- Fungicides available to USA sunflower growers change over time, and periodic evaluation of efficacy provides important information to growers that help them make the best decisions for their farms.
- The objective of this study was to evaluate efficacy of multiple fungicides.

Materials & Methods

- This trial was conducted in Casselton, ND (2024) and Prosper, ND (2025) in a Randomized Block Design with six treatments replicated four times each year.
- Labeled fungicides were chosen based on product availability to growers and diversity of mode of action (Table 1).
- The trial was planted into four-row plots spaced 30 inches and 20 feet long.
- The experiment was inoculated with urediniospores at canopy closure with a field-collection of *P. helianthi* originally collected from North Dakota in 2023 and 2024 in a solbrol suspension using a leaf blower.
- Fungicides were applied at R5 (two weeks after pathogen inoculation) using a hand-held 3 nozzle boom above the sunflower heads with flat fan nozzles at a rate of 20 gal/acre. A non-ionic surfactant was included in all treatments.
- The experiment was evaluated for rust severity by visually examining ten arbitrarily-selected leaves from the upper canopy in each plot using the severity scale (Figure 3, Feiskop et al. 2011). Evaluation was conducted two times for each respective year, beginning two weeks after fungicide application.

Figure 1.
a. Prosper trial at growth stage R5
b. Leaf blower used for inoculation
c. Boom sprayer used for fungicide application

Figure 3.
Sunflower rust severity reference rating chart

Results

Table 1. Treatment number, treatment name, active ingredient, mode of action, and rate utilized for this study are displayed below

Treatment Number	Treatment Name	Active Ingredient	Mode of Action and Group	Rate
1	Non Treated Control (Check)	-	-	-
2	Onset	Tebuconazole	DMI (3)	4 fl oz/a A
3	Quadris	Azoxystrobin	QoI (11)	6 fl oz/a A
4	Luna Experience	Fluopyram + Tebuconazole	SDHI (7) + DMI (3)	9 fl oz/a A
5	Priaxor	Fluxapyroxad + Pyraclostrobin	SDHI (7) + QoI (11)	4 fl oz/a A
6	Headline	Pyraclostrobin	QoI (11)	6 fl oz/a A

Figure 4. 2024 and 2025 mean rust severity for fungicide treatment at Growth Stage R5

Figure 5. 2024 and 2025 mean rust severity for fungicide treatment at Growth Stage R6/R7

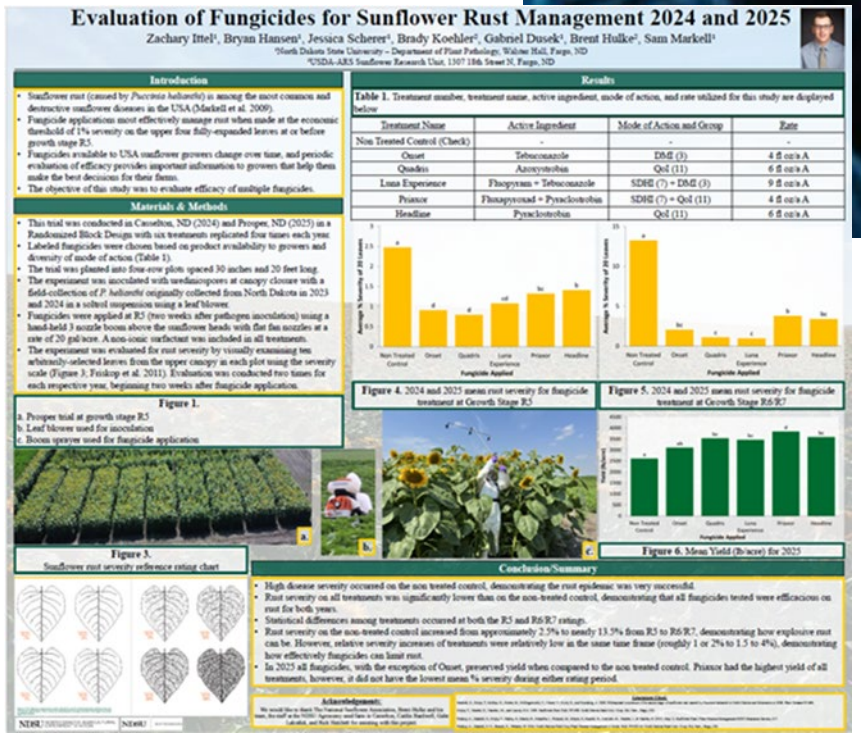
Figure 6. Mean Yield (lb/acre) for 2025

Conclusion/Summary

- High disease severity occurred on the non treated control, demonstrating the rust epidemic was very successful.
- Rust severity on all treatments was significantly lower than on the non-treated control, demonstrating that all fungicides tested were efficacious on rust for both years.
- Statistical differences among treatments occurred at both the R5 and R6/R7 ratings.
- Rust severity on the non-treated control increased from approximately 2.5% to nearly 13.5% from R5 to R6/R7, demonstrating how explosive rust can be. However, relative severity increases of treatments were relatively low in the same time frame (roughly 1 or 2% to 1.5 to 4%), demonstrating how effectively fungicides can limit rust.
- In 2025 all fungicides, with the exception of Onset, preserved yield when compared to the non treated control. Priaxor had the highest yield of all treatments, however, it did not have the lowest mean % severity during either rating period.

Additional/Future Objectives

- *Puccinia helianthi* population genetic analysis
- Whole Genome Pathogen Sequencing
- SAM pop experiment
- Fungicide evaluation



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Project Update Summary

- Prevalence = Does rust occur in a field? (Yes/Fields Surveyed)
- Virulence = Can the pathogen overcome a resistance gene?
- Future directions



Acknowledgements

Survey Help:

- **ND** (County Agents, NSA Board members, and Farmers)
- **SD** (Mr. Weber, NSA Board members, Farmers, and Dr. Febina Mathew's Team)
- **NE** (Dr. Bob Harveson and his team)
- **WI** (Dr. Brandt Berghuis and his team)
- **MN** (Farmers)

Other Pivotal Help:

- Dr. Bill Underwood
- Scott Radi
- John Sandbakken
- Kaylie Schlecht
- Caitlin Bardwell
- Gabe Lakoduk
- Rick Hatchet
- Jessica Scherer
- Bryan Hansen

National Sunflower Association

NDSU Plant Pathology

Thank you

Questions?