Bridging the bench and the field:

Understanding and Managing Sclerotinia Stem Rot of Canola

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2022 Canola Symposium

December 1, 2022

Assistant Professor of Plant Pathology and Fungal Biology

- Research focus: soilborne fungi that cause crop diseases
  - **Improved management:** ecology and epidemiological considerations
  - **Enhancing host disease resistance:** genetic strategies that harness fungal biology
- Position funded through AGREETT
- Position start date: August, 2021
- 50% Research and 50% Teaching
- Feel free to send me an email if you have questions or would like to chat:

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  mmccaghe@umn.edu

Enhancing soybean resistance to Sclerotinia stem rot (*Sclerotinia sclerotiorum*)

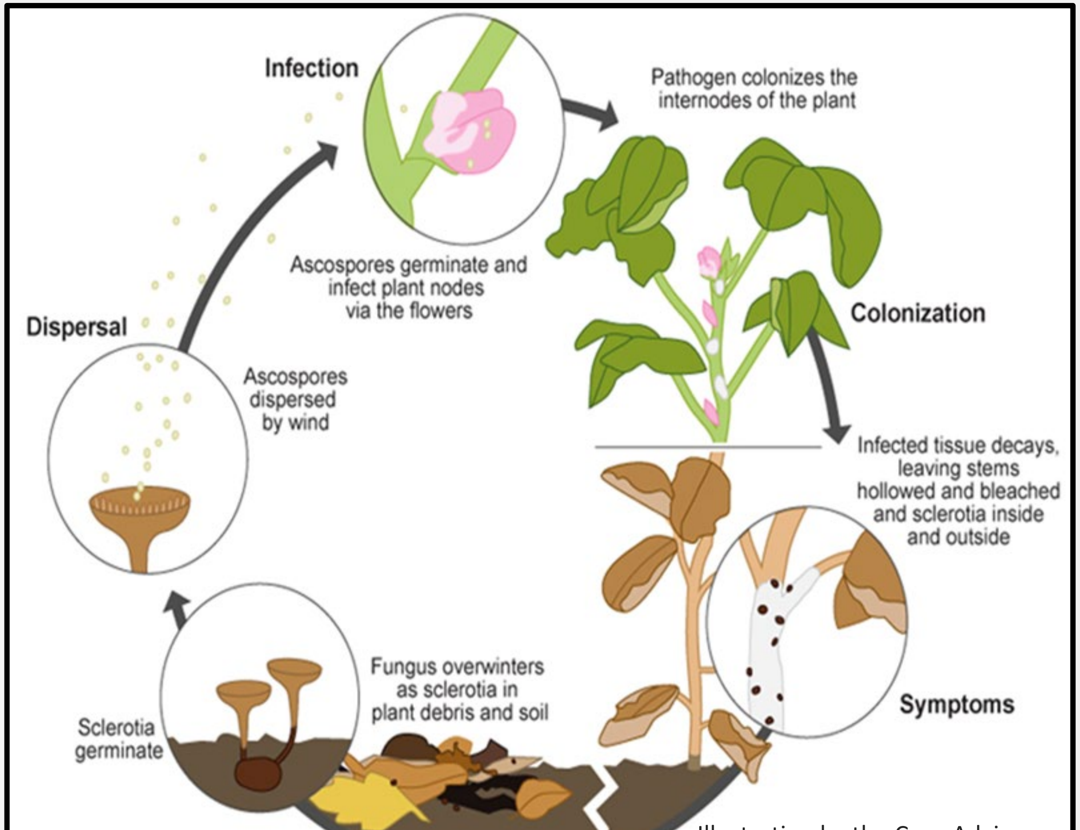


Illustration by the Crop Advisor Institute


Sclerotinia stem rot is a destructive disease

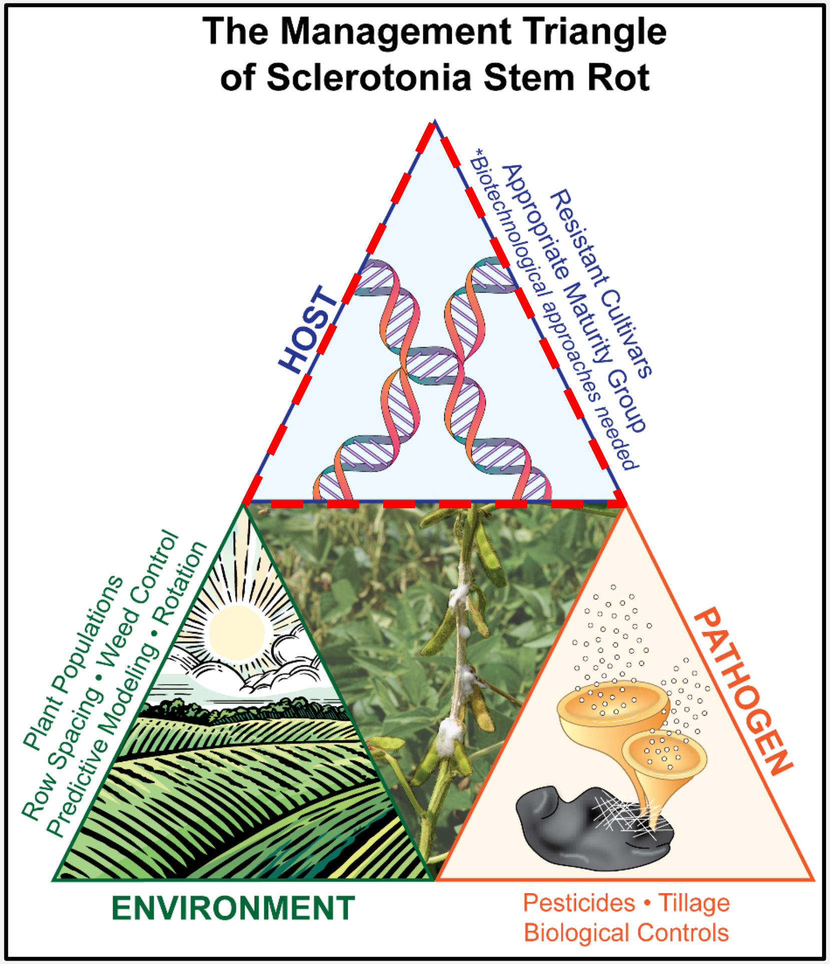
Sclerotinia stem rot is a destructive disease

Bleached lesions and poor pod fill

Wilt and lodging

Sclerotinia stem rot challenges

- *S. sclerotiorum* has a wide host range, >400 hosts.
- Sclerotia persist in the soil.
- Chemical management can be effective for some crops, but application windows are narrow.
- Strong resistance is lacking in commercial cultivars.



Willbur, J., McCaghey, M., Kabbage, M., & Smith, D. L. (2019). An overview of the *Sclerotinia sclerotiorum* pathosystem in soybean: impact, fungal biology, and current management strategies. *Tropical Plant Pathology*, *44*(1), 3-11.

Solutions to enhance SSR resistance in soybean:

1. Development of germplasm lines resistant to SSR through late generation selection and crossing using novel forms of resistance, diverse genetics, and multi-environment evaluations.

2. Host induced gene silencing (HIGS) to target the production of an important pathogenicity factor, oxalic acid.

Wisconsin Soybean Marketing Board

National Sclerotinia Initiative

The Storkan Hanes McCaslin Research Foundation

Solutions to enhance SSR resistance in soybean:

1 Development of germplasm lines resistant to SSR through late generation selection and crossing using novel forms of resistance.

First Stage of Breeding

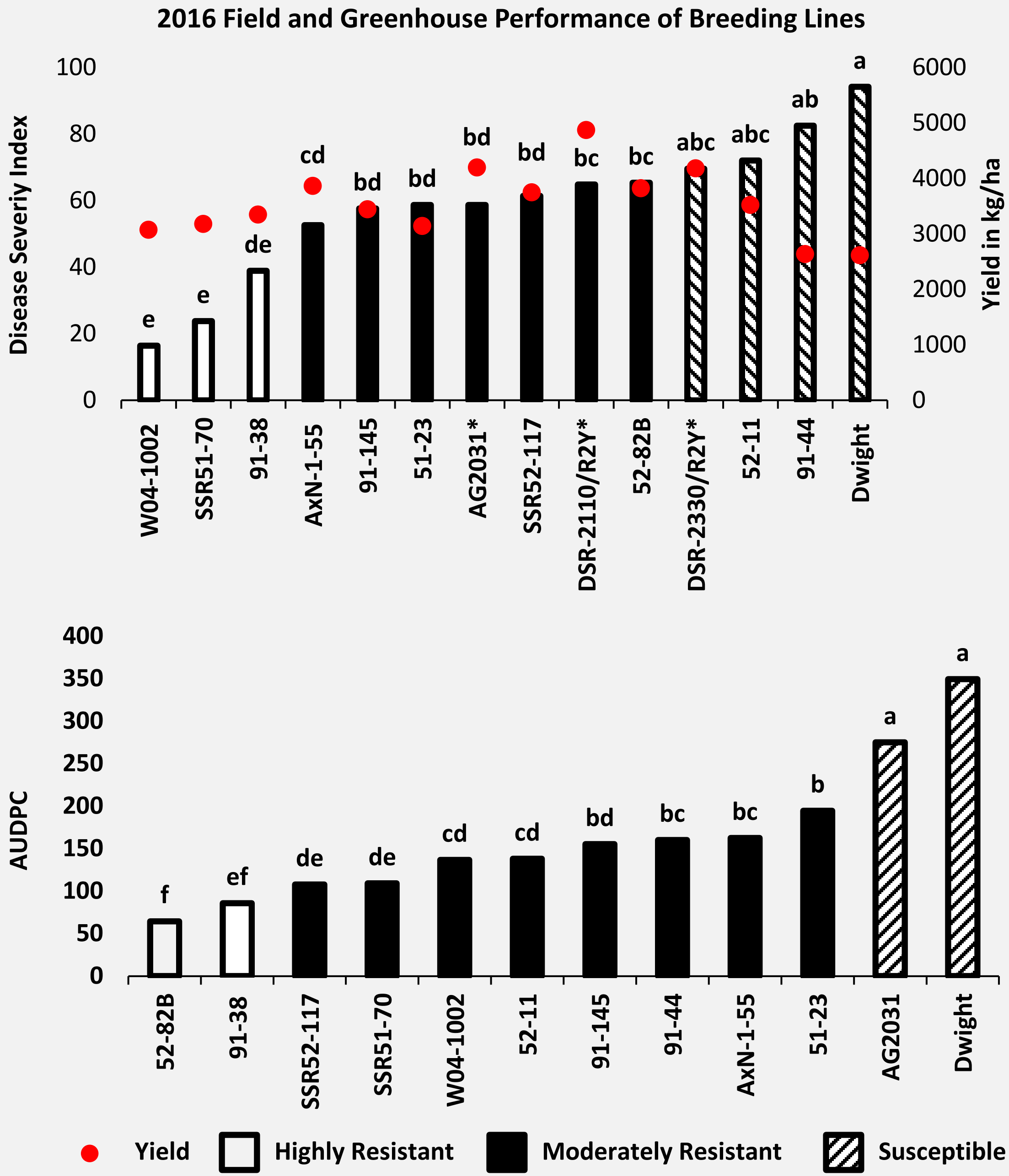
- Late generation selection
- Select physiological SSR resistance
- Select for agronomics
- Generate commercial cultivars

Second Stage of Breeding

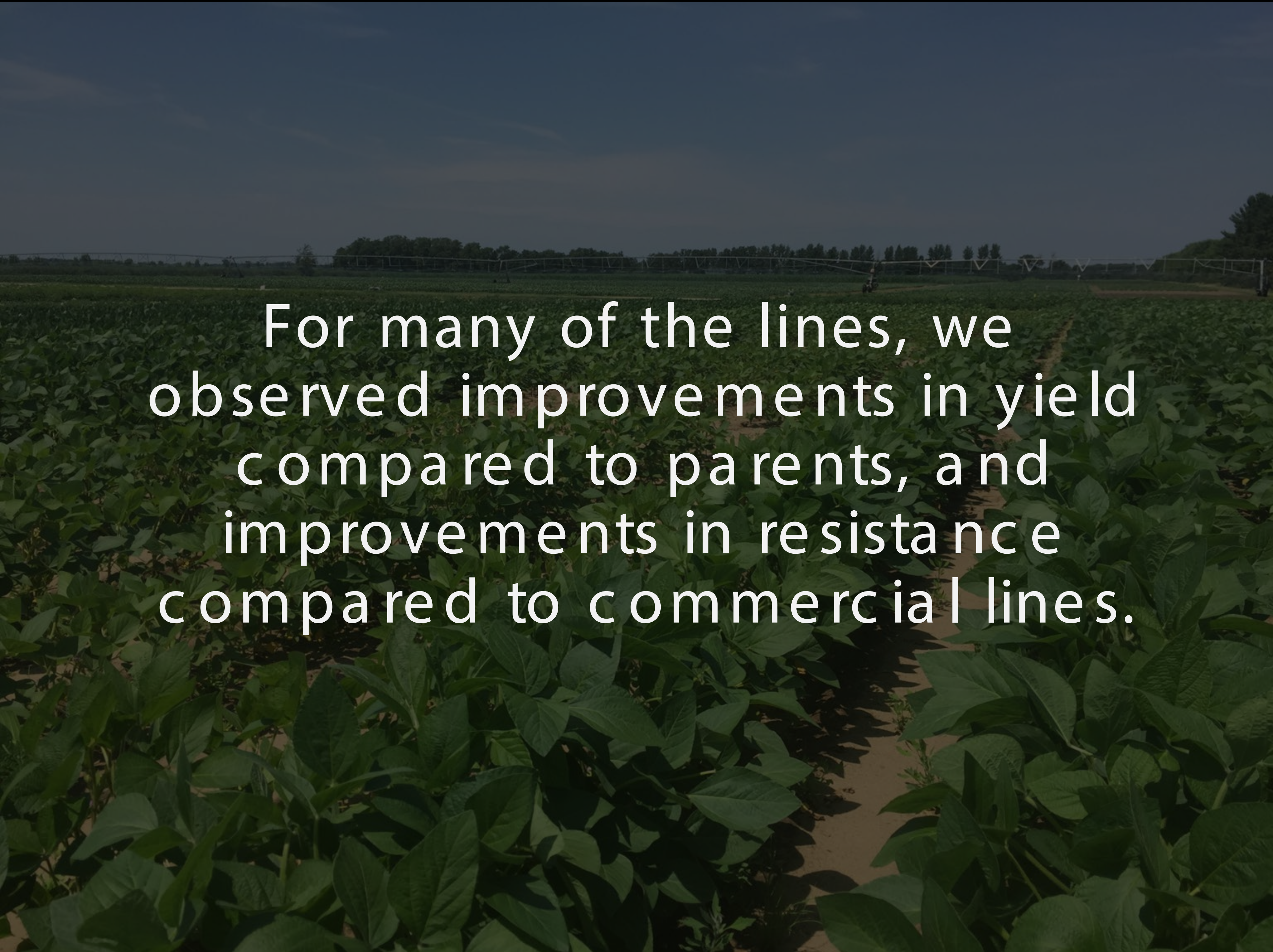
- Combine SSR resistance of lines
- Select for consistent performance across environments

Third Stage of Breeding

- Improve agronomics
- Combine SSR resistance of lines



Average 2016 yield in WI: 3,946.90 kg/ha


For many of the lines, we observed improvements in yield compared to parents, and improvements in resistance compared to commercial lines.

Summary of initial SSR resistance breeding efforts

Breeding with a novel source of white mold resistance followed by **greenhouse and field screening**, resulted in the development of several promising soybean lines for release as cultivars or use as parents in breeding programs.

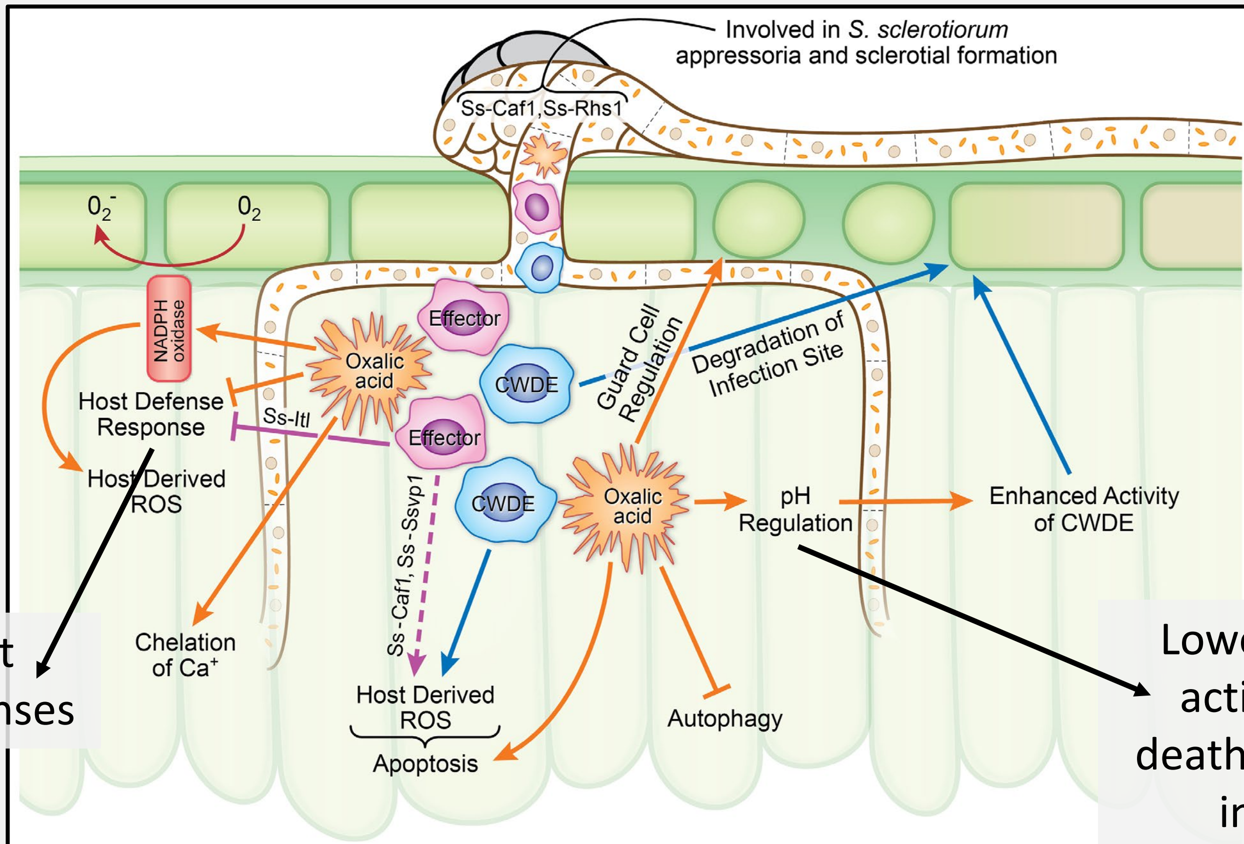
Line	High Res.	Mod Res.	High Yield	High Protein and Oil	Low Lodging	Novel QTL Marker
★ 91-38	✓	✓		✓	✓	✓
52-82B	✓	✓	✓	✓	✓	
SSR51-70	✓			✓	✗	
51-23		✓			✓	

Solutions to enhance SSR resistance in soybean:

2 Host induced gene silencing (HIGS) to target the production of an important pathogenicity factor, oxalic acid

Oxalic acid (OA) is an important pathogenicity factor

Oxalic acid is multifunctional in *S. sclerotiorum*



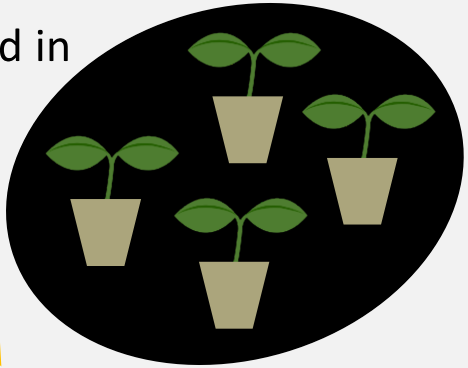
Inhibits host defense responses

Lowers pH and activates cell death needed for infection

McCaghey, M., Willbur, J., Smith, D. L., & Kabbage, M. (2019). The complexity of the *Sclerotinia sclerotiorum* pathosystem in soybean: virulence factors, resistance mechanisms, and their exploitation to control Sclerotinia stem rot. *Tropical Plant Pathology*, *44*(1), 12-22.

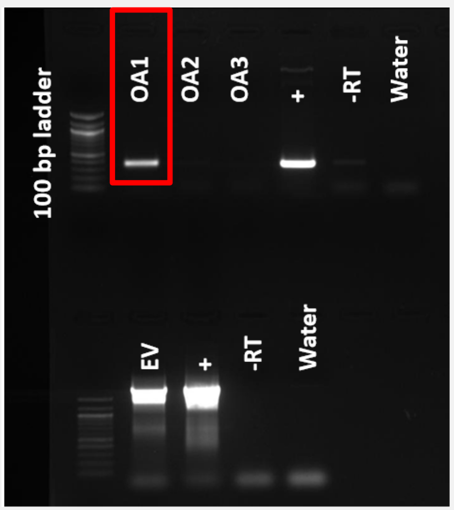
Soybean were inoculated with the BPMV vector containing a silencing construct for *Ss-oah1*

10 day old seedlings were placed in the dark.



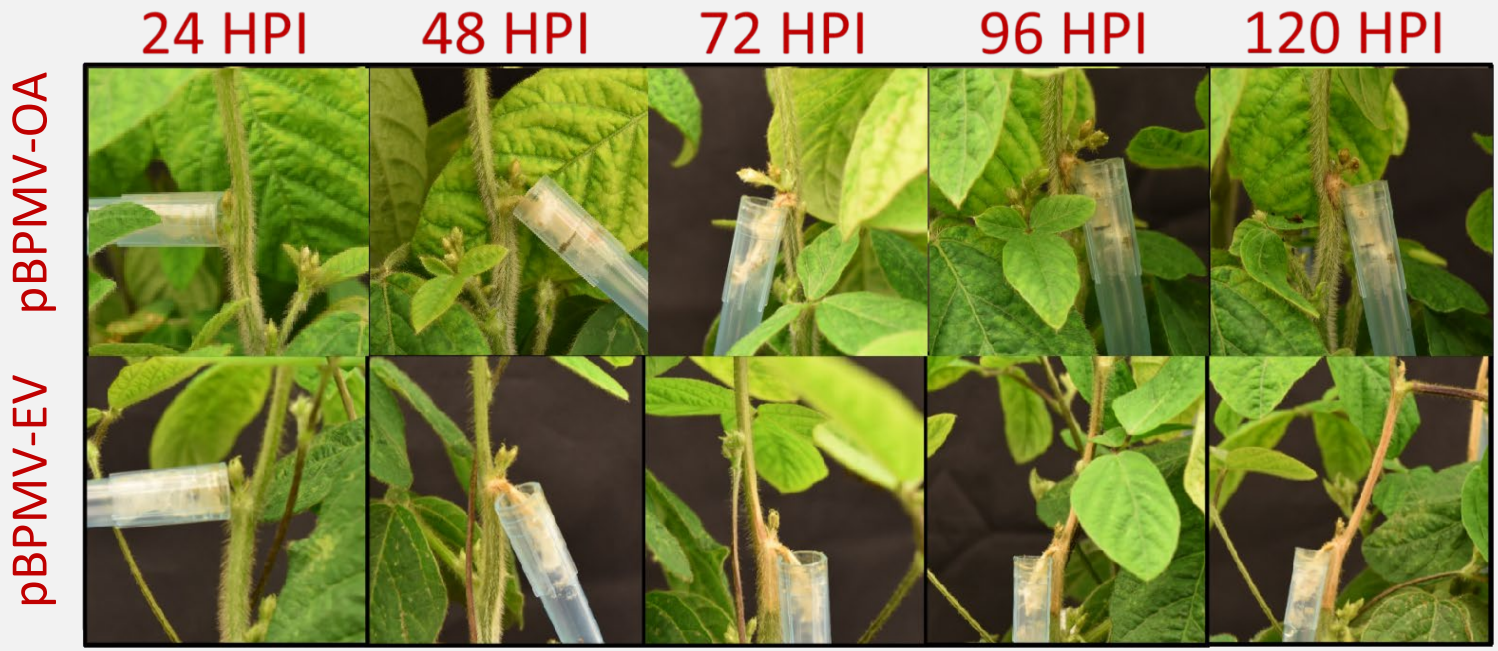
Biolistically inoculated Williams 82 with RNA2 + RNA1

Traff were rub inoculated for experiments.

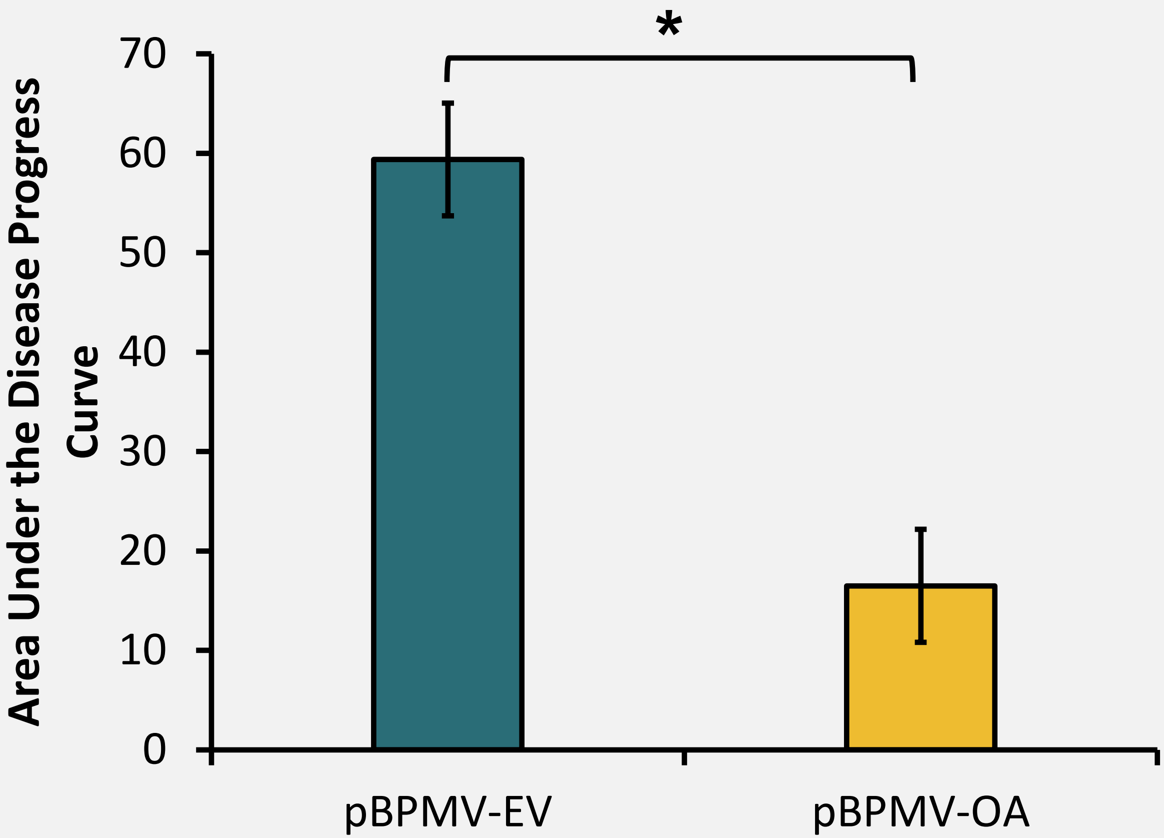


Confirmed with phenotype and RT-PCR and

Visual differences in lesions were apparent



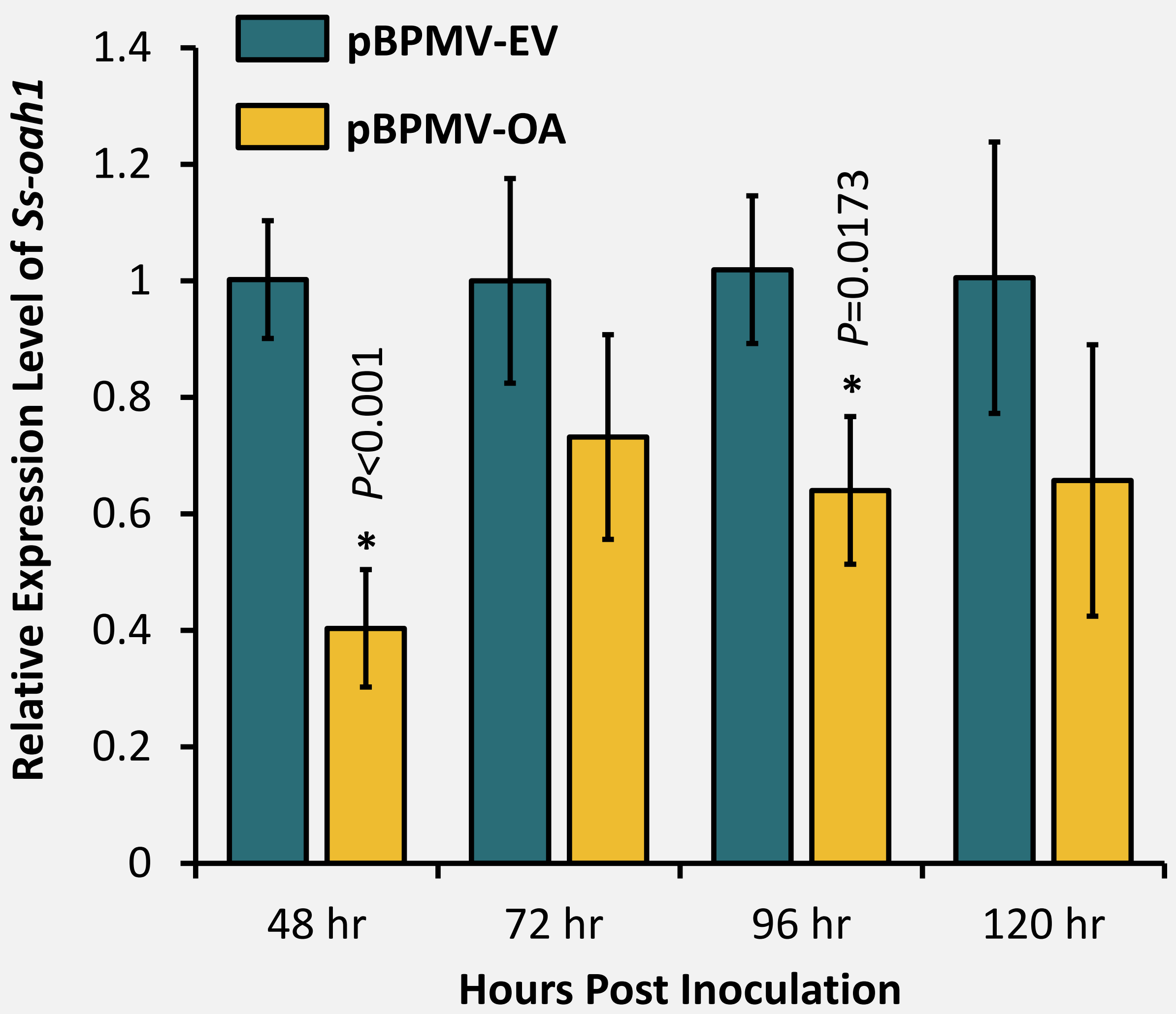
Lesion development was delayed and lesions were smaller in the pBPMV-OA plants, whereas EV-containing plants had large, often girdling, lesions at 96 HPI.



AUDPC was lower in RNAi plants

(P=0.0012)

- Lesions measured 1-5 DPI
- Three, independent experimental runs



Expression of ***Ss-oah1*** decreased in RNAi plants

- RNA extracted from 6 cm stem tissue collected 48-120 HPI
- Three, independent experimental runs

Outcomes to enhance SSR resistance

- **Four lines** identified as candidates for future SSR resistance breeding programs
- Dane (91-38) is commercially available
- First soybean crosses in the Smith Lab: aim to enhance SSR resistance and agronomic properties
- Expedited selection process
- RNAi targeting *Ss-oah1* has promise as a transgenic option or biopesticide
- Results presented at fields days, extension, and academic meetings

Developing my research program in soil-associated fungal pathogens at the University of Minnesota

Collaborative Vision

1) Launching my program:

- Getting to know stakeholders (commodity boards, growers) to better understand their research needs.
- Talking to potential collaborators and gaining institutional knowledge.

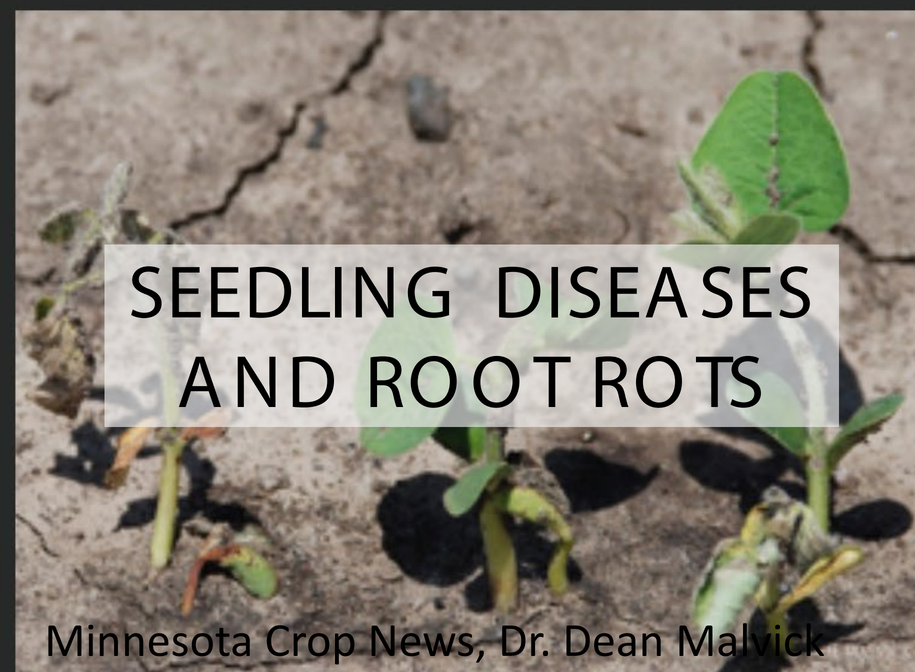
2) Sustaining an innovative program:

- Lead and collaborate with regional, national, and international experts and industry members to advance knowledge in soil-associated fungi and oomycetes.


SCLEROTINIA
STEM ROT
Canolacouncil.org

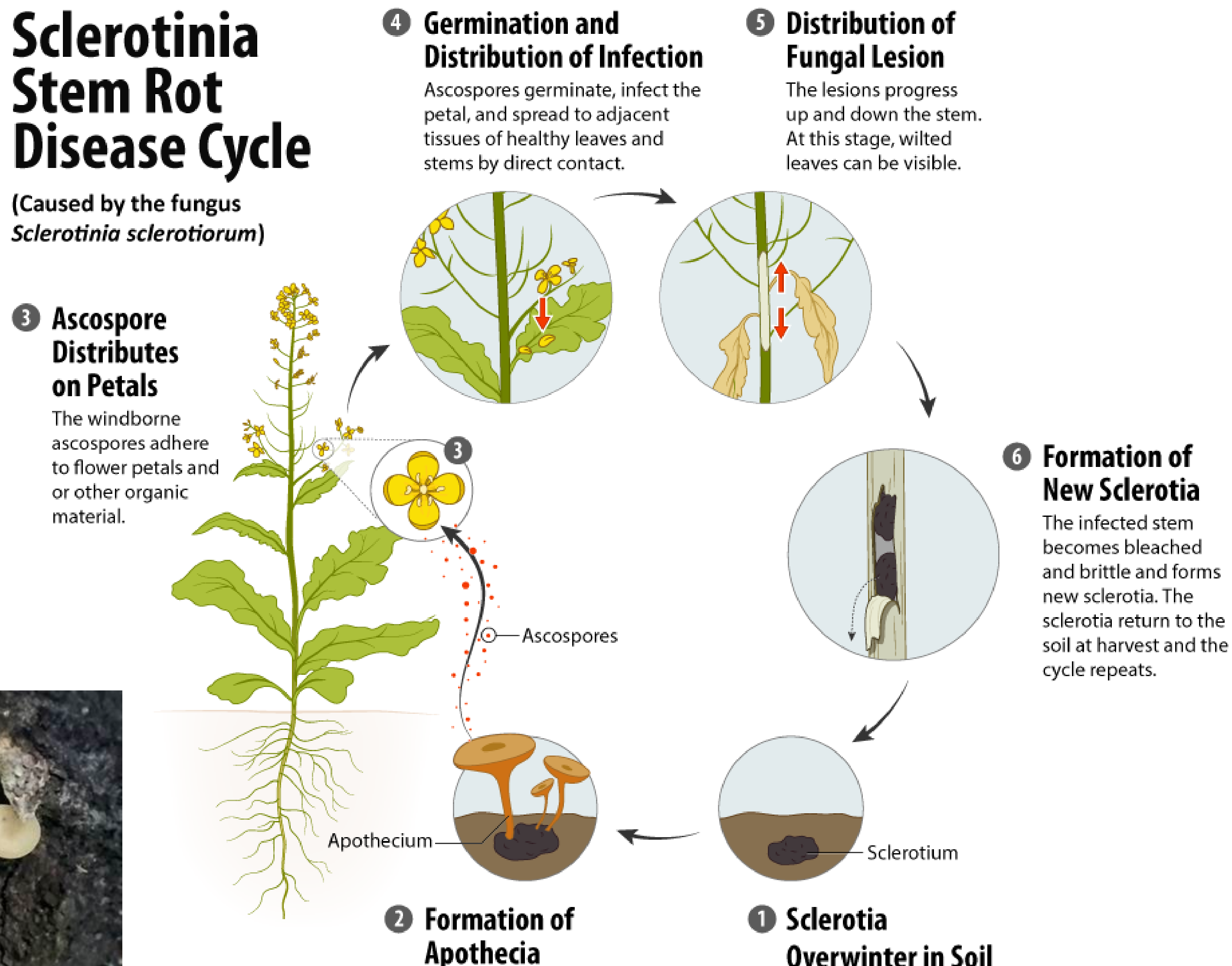

CLUB ROOT
Canolacouncil.org


BLACKLEG
Canolacouncil.org


SEEDLING DISEASES
AND ROOT ROTS
Minnesota Crop News, Dr. Dean Malvick

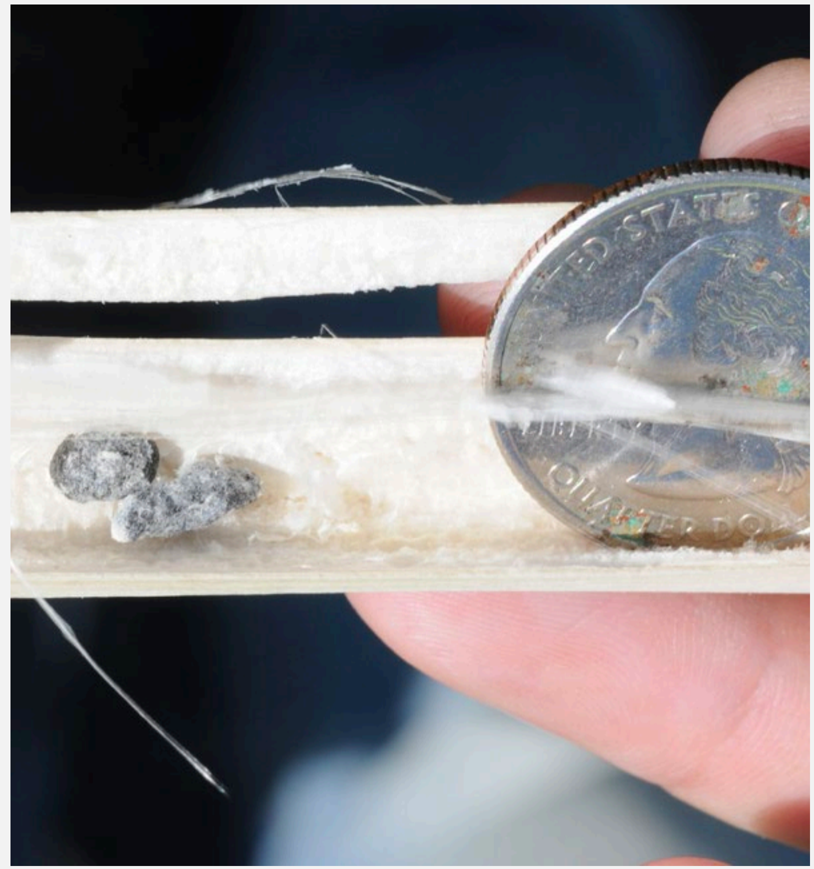
Sclerotinia stem rot in canola- impact

- Can cause yield losses up to 50%
- Many susceptible hosts grown in MN: soybean, dry beans, sunflowers
- All canola varieties are susceptible
- Difficult to control- wide host range and sclerotia persist for a long time
- Fungicide applications are most beneficial at early flowering stages, during risk windows



https://www.canolacouncil.org/

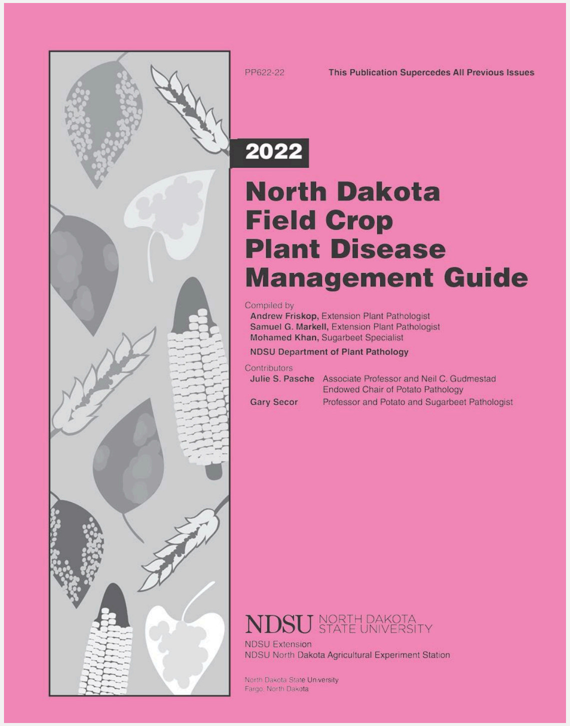
Sclerotinia stem rot in canola- signs and symptoms

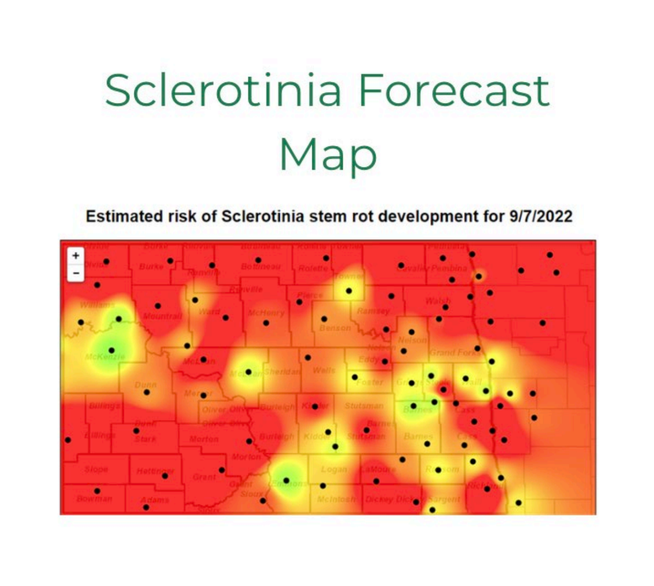


Sam Markell, NDSU

Sclerotinia stem rot in canola- management

- Fungicide application timing is critical (20-50% of flowering)- look for apothecia
- Forecasting tools are available
- Various options: Ex. Boscalid and Azoxystrobin AI
- Hybrids with tolerance and upright architecture
- Rotation with non-susceptible crops (grasses) to reduce inoculum



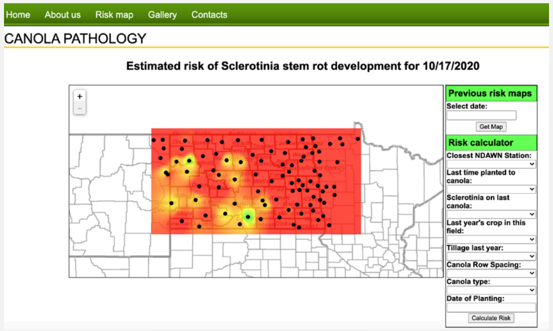


Dr. Sam Markell
Dr. Luis Del Rio
www.ag.ndsu.edu


Our aim to address management challenges:
Understand the ecology and epidemiology of soil-associated fungi and oomycetes and enhance host disease resistance to improve management.

Potential research questions: *S. sclerotiorum*

- **The impact of agricultural practices on pathogen ecology and pathogenicity:**
  - Amendments/cover crops and survival
  - Co-managing for soil health and disease suppression
- **Collaborate on forecasting/risk work:**
  - Generate check panels of canola lines
  - Compare relative to commercial varieties
  - Potentially incorporate variety into risk models
- **Enhancing crop resistance:**
  - Targeting one or multiple pathogenicity factors using RNAi SIGS(work in various crops)
  - When can resistance in combination with IPM or plant architecture protect yield?



www.northerncanola.com

badgercropdoc.com/

Current research questions: enhancing crop protection using fungal biology

- Plant architecture considerations in *S. sclerotiorum* (Ss) infection and breeding of soybean (in collaboration with Dr. Lorenz)
- Characterize MN *Ss* isolates for res. screening in various crops
- Understanding Ss aggressiveness determinants across hosts and targeting using RNAi

Biotech approaches for SSR management (SIGS), genetics of Ss light responses and methods to alter the microenvironment

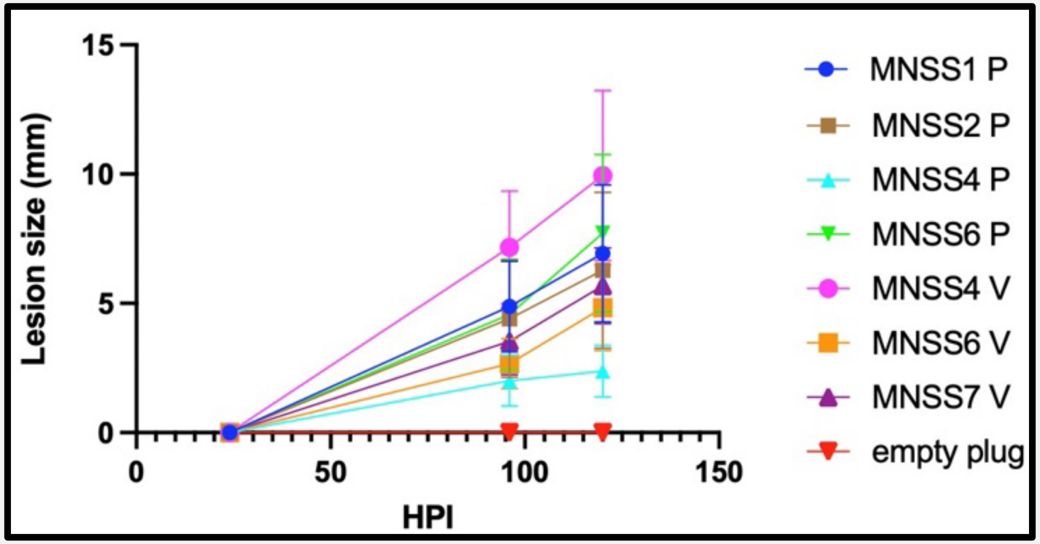
MINNESOTA SOYBEAN
RESEARCH & PROMOTION COUNCIL

Ex 1. Co-managing for soil health and disease suppression with cover crops

- Collaboration with Drs. Angie Peltier and Anna Cates
- CC can improve soil properties (important in NW MN- compacted soils and water logging)
- CCs can change microbial communities and reduce disease pressure
- Winter rye or brown mustard's effects on *S. sclerotiorum*?

Future directions: identifying and managing for microbial communities that degrade resting structures, developing forecasting models, multistate management projects

Ex 2. Understanding Ss aggressiveness determinants and developing screening panels

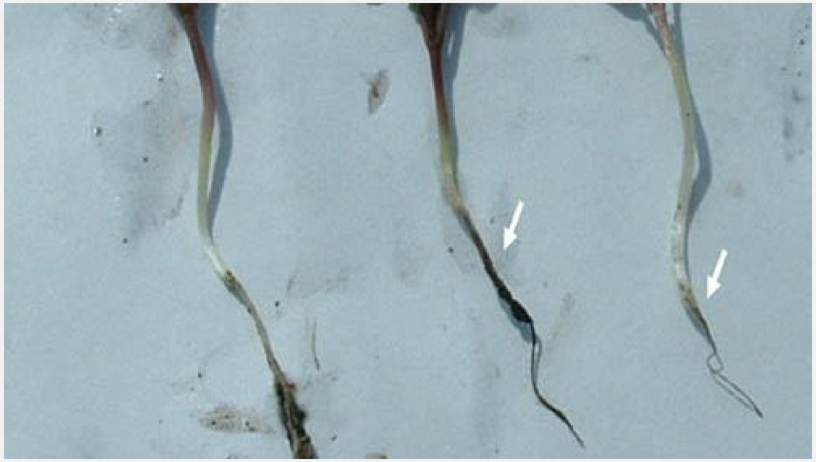


Lesion size on soybean at 24, 96, and 120 hrs after being inoculated (HPI) with seven isolates of Sclerotinia sclerotiorum. Graph provided by graduate student, Hsuan-Fu Wang

Potential soilborne fungi research questions in changing agricultural systems

- Plant stress and disease with flooding, drought, irrigation
- Monitor for resistance breaking races of fungi (*Leptosphaeria maculans)*
- Monitor and predict changes in populations of stress and temp. sensitive fungi (*Fusarium and L. maculans*)
- Monitor emerging diseases: Charcoal rot (*Macrophomina phaseolina*)

Ex: irrigation and water stress studies



www.canolacouncil.org

- Evaluating the impact of irrigation on disease risk and developing predictive tools (white mold seedling diseases)
- Will also provide the opportunity to study the impact of crop stress on disease development

Future directions: developing irrigation-based forecasting models, multistate management/monitoring projects

THANK YOU

Questions?

- Additional ideas or concerns?

Please email me: mmccaghe@umn.edu