Technical Report

Project Title: Validation of Sclerotinia sclerotiorum Apothecial Prediction Models in North Dakota and Evaluation of Soybean Resistance to White Mold

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Research Overview and Objectives:

Background information and research gaps.

White mold, caused by the fungal pathogen *Sclerotinia sclerotiorum*, poses a significant threat to soybean production in the Upper Midwest, including North Dakota. The disease is highly dependent on environmental conditions, leading to inconsistent and unpredictable epidemics, which complicates effective management. Traditionally, farmers rely on fungicide applications to control white mold, but these treatments can be costly, and their necessity changes annually based on the weather conditions present in each year. Current predictive models such as Sporecaster have been developed using data from states like Wisconsin, Iowa, and Michigan, and have shown efficacy in those regions but have not been specifically validated for North Dakota's diverse growing conditions. Further, there could be distinct populations of *S. sclerotiorum* that may require adjustments to these models. This research aims to fill this gap by assessing and improving the accuracy of Sporecaster models for North Dakota, helping farmers make more informed decisions about fungicide applications and potentially reducing unnecessary treatments. Additionally, the project seeks to identify soybean germplasm lines with varying levels of resistance to white mold, providing a valuable resource for future breeding efforts aimed at developing more resistant soybean varieties. This approach of investigating predictive model accuracy and advancing genetic resistance addresses the need for more reliable and cost-effective white mold management strategies, ultimately supporting the profitability and sustainability of soybean farming in North Dakota.

Research Objectives:

1. The accuracy of predictive models (Sporecaster) for predicting white mold of soybean will be determined for North Dakota soybean production fields.
2. Soybean breeding lines and additional PI lines will be screened for resistance to *Sclerotinia sclerotiorum*
    a. A panel of soybean genotypes adapted to North Dakota will be identified with consistent resistance responses to *Sclerotinia sclerotiorum* for use as standard controls in future greenhouse and field experiments

Materials and Methods:

During the 2023 growing season, our team, in collaboration with NDSU county Extension agents, performed field scouting across North Dakota to monitor for the presence/absence of apothecia and to assess white mold disease incidence. Targeting fields with a known history of white mold, we scouted during the flowering periods (R1-R3 growth stages) to identify the presence or absence of apothecia, the fungal structures that release spores into the crop canopy leading to white mold development. During the R6 growth stage, we also began scouted fields for the presence of white mold and recorded the % or diseased plants, called disease incidence. Scouting involved walking in a "W" pattern through each field and stopping at 20 random locations to count the number of apothecia or diseased plants within a 1-meter section of row. This method provided a comprehensive field-level white mold incidence score by averaging the disease incidence ratings from these spots. The GPS coordinates of each field were recorded, and weather data were retrieved from IBM weather services to calculate daily risk probabilities as determined by the Sporecaster models. This approach allowed us to validate and potentially adjust the model's action thresholds specifically for non-irrigated fields in North Dakota.

We also performed greenhouse screenings of 49 soybean PI lines from the USDA-GRIN with maturity groups between 000 and 1 to evaluate their resistance to *S. sclerotiorum*. Using a highly aggressive isolate of the pathogen (WI-20), we inoculated soybean plants at the V4-V5 growth stage using the cut-petiole technique. Alongside these PI lines, we included four soybean genotypes with known levels of resistance to serve as checks: 52-82B (resistant), SSR51-70 and 51-23 (moderately resistant/susceptible), and Dwight (susceptible). Plants were grown under controlled greenhouse conditions, and resistance was measured by observing lesion development on the main stems at three independent time points. These observations were used to calculate the Area Under the Disease Progress Curves (AUDPC values) for each genotype. This screening process aimed to identify PI lines with varying degrees of resistance, which could be utilized in future breeding efforts to develop soybean varieties with enhanced resistance to white mold.

Research Findings/Outcomes:

The field scouting conducted during the 2023 growing season revealed that the development of white mold in North Dakota soybean fields may differ from the production systems in the Great Lakes region where Sporecaster was developed. We scouted a total of 16 fields and found that the Sporecaster predictive models were highly effective in forecasting white mold development when adjusted. Specifically, our analysis indicated that an action threshold of 30% was more accurate for recommending fungicide applications in non-irrigated fields, compared to the default 40% threshold used by Sporecaster. This adjustment significantly improved the precision of disease management recommendations, helping farmers make appropriate applications and avoid unnecessary fungicide treatments. The field-level white mold incidence scores, combined with site-specific weather data, create a dataset for further refining the predictive models to better suit North Dakota's diverse growing conditions.

The greenhouse screening of 49 soybean PI lines also led to valuable results. Among the PI lines tested, multiple lines exhibited high levels of resistance to *Sclerotinia sclerotiorum*, with significant differences ($P < 0.01$) identified across the genotypes. Notably, several PI lines had comparable resistance ratings to

the highly resistant check genotype 52-82B. Additionally, we identified highly susceptible lines (e.g., PI 458535 and PI 548601), which could serve as important checks for future genetic research and breeding programs. The AUDPC values calculated for each genotype provided a clear ranking of resistance levels, enabling the selection of the most promising lines for further field trials. These findings are critically important for breeding new soybean varieties with improved resistance to white mold, ultimately supporting more effective and economical disease management strategies for North Dakota soybean farmers.

Disclosure of Inventions or Plant Varieties:

None

Discussion:

The results of this study demonstrate the importance of region-specific validation and adjustments of predictive models like Sporecaster for effective disease management in North Dakota soybean fields. By identifying a more accurate action threshold of 30% for non-irrigated fields, we have provided farmers with a more reliable tool for making informed fungicide application decisions. This adjustment not only helps reduce unnecessary fungicide treatments, thereby saving costs, but also enhances the overall sustainability of soybean farming in the region. The success of these initial validations suggests that continued data collection and model refinement during the coming growing seasons are essential to ensure robust and adaptable recommendations across varying weather conditions. Comprehensive multi-season data will help in fine-tuning the model, making it a critical decision support tool for soybean growers facing the challenges of white mold.

The greenhouse screening of soybean PI lines has identified several promising candidates with high levels of resistance to *Sclerotinia sclerotiorum*, providing a valuable genetic resource for future breeding programs. These resistant lines, once validated in field conditions under natural white mold pressure, can be used to develop new soybean varieties with enhanced disease resistance. Further, the identified resistant and susceptible lines can serve as new check lines specific to North Dakota, facilitating more accurate resistance assessments in future studies. Evaluating these lines against multiple isolates of *S. sclerotiorum* will be crucial to understanding the robustness of their resistance. Additionally, these lines present opportunities for in-depth genetic studies to elucidate the mechanisms underlying resistance, potentially leading to breakthroughs in breeding strategies and the development of even more resilient soybean varieties. The integration of these findings into breeding and management practices will ultimately contribute to higher yields, reduced input costs, and improved profitability for soybean farmers in North Dakota.

Benefits to North Dakota Soybean Farmers and Industry:

This research offers significant benefits to North Dakota soybean farmers by enhancing their ability to manage white mold more effectively and economically. By refining the Sporecaster predictive models to be more accurate for local conditions, farmers can make better-informed decisions regarding fungicide applications, reducing unnecessary treatments and associated costs. This leads to more sustainable farming practices and helps maintain profitability even in years with lower disease pressure. Additionally, the identification of soybean lines with high levels of resistance to *S. sclerotiorum* provides farmers with new, more resilient soybean varieties. These varieties can help mitigate the impact of white mold, reducing reliance on chemical controls and further lowering input costs. By integrating both improved predictive tools and enhanced genetic resistance, this research empowers farmers with more effective strategies for maintaining high yields and overall farm profitability, ultimately supporting the sustainability of soybean farming in North Dakota.

Acknowledgements:

We would like to thank all the county Extension agents who assisted in identifying fields with a history of white mold present. We would also like to acknowledge the farmers who allowed us to scout their fields throughout the season. Finally, we would like to thank the North Dakota Soybean Council for their support in this research.

Figure Captions:

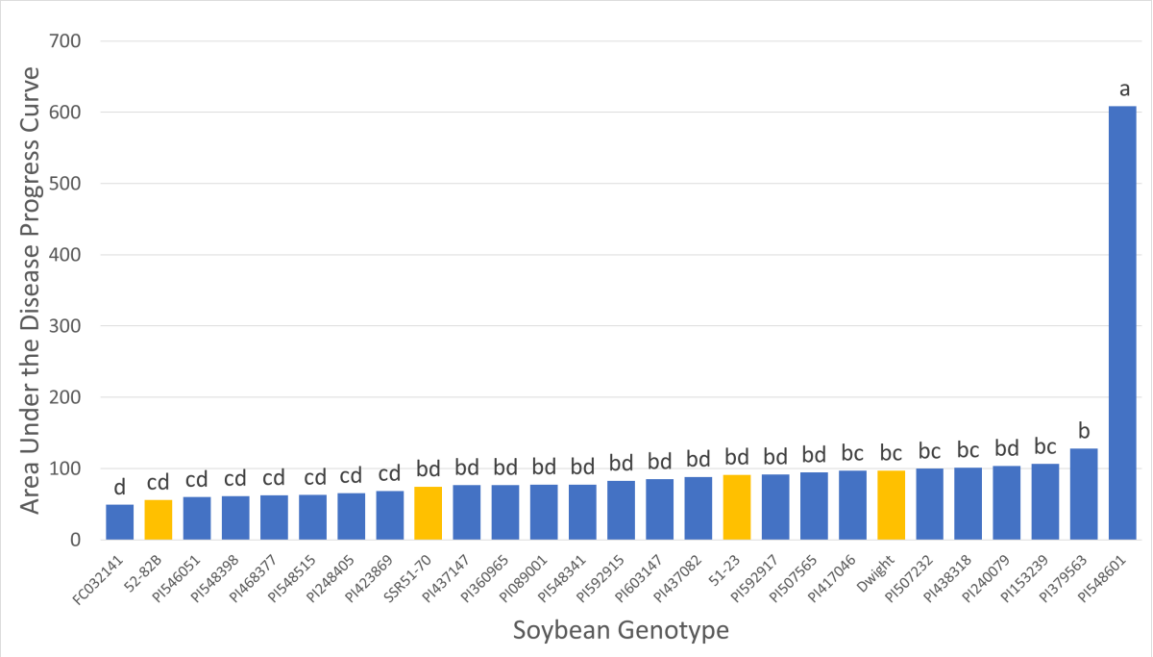

Figure 1. Evaluation of early maturity soybean germplasm lines for resistance to *Sclerotinia sclerotiorum* under greenhouse conditions. The gold bars represent four soybean check lines with known levels of resistance (52-82B – Resistant, SSR51-70 and 51-23 – Moderately Resistant/Susceptible, and Dwight – Susceptible). Soybean lines that share letters do not differ as determined by Fisher's LSD (a = 0.05).

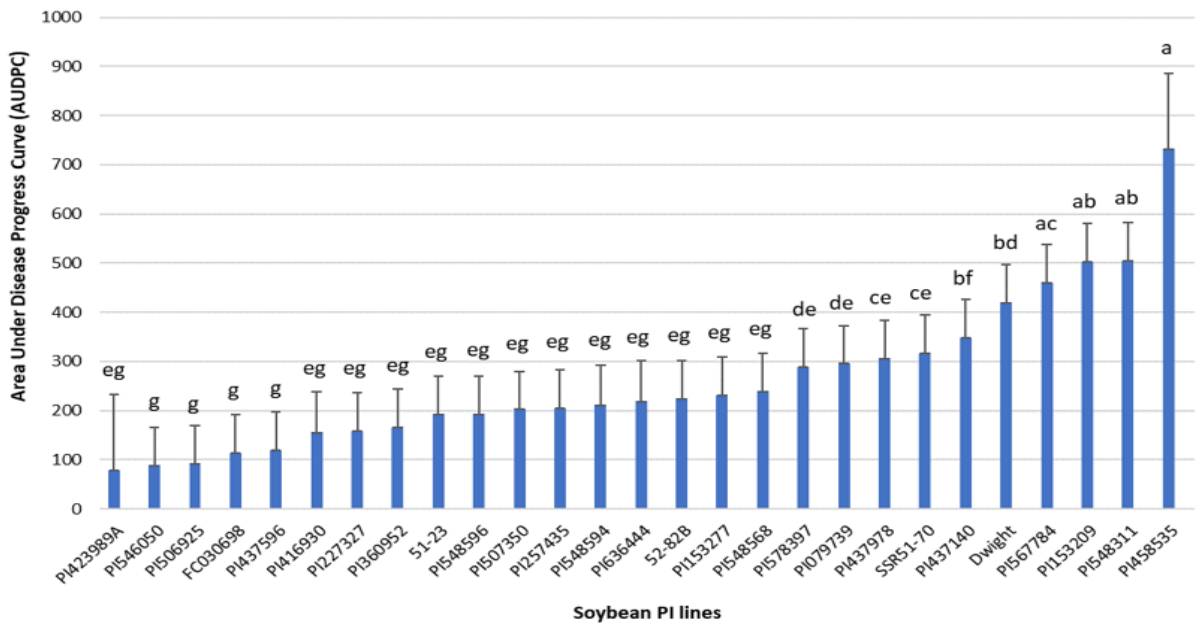

Figure 2. Evaluation of early maturity soybean germplasm lines for resistance to *Sclerotinia sclerotiorum* under greenhouse conditions. Four soybean check lines with known levels of resistance levels are used as controls (52-82B – Resistant, SSR51-70 and 51-23 – Moderately Resistant/Susceptible, and Dwight – Susceptible). Soybean lines that share letters do not differ as determined by Fisher's LSD (a = 0.05).

					Risk ≥Threshold (R1-R4)			Success or Failure at 5% DI			Success or Failure at 10% DI		
FieldID	Max_Proba	DI	DI5	DI10	20	30	40	20	30	40	20	30	40
F-1	32.966268	55.6	1	1	1	1	0	1	1	0	1	1	0
F-2	36.249276	91.3	1	1	1	1	0	1	1	0	1	1	0
F-3	44.2714	34.3	1	1	1	1	1	1	1	1	1	1	1
F-4	42.17335	63.2	1	1	1	1	1	1	1	1	1	1	1
F-5	12.17358	0	0	0	0	0	0	1	1	1	1	1	1
F-6	16.7613	0	0	0	0	0	0	1	1	1	1	1	1
F-7	19.15643	0.1	0	0	0	0	0	1	1	1	1	1	1
F-8	12.8678	0	0	0	0	0	0	1	1	1	1	1	1
F-9	12.8678	0	0	0	0	0	0	1	1	1	1	1	1
F-10	10.399	0	0	0	0	0	0	1	1	1	1	1	1
F-11	30.1387	0	0	0	1	1	0	0	0	1	0	0	1
F-12	17.5669	0	0	0	0	0	0	1	1	1	1	1	1
F-13	26.99836	0	0	0	1	0	0	0	1	1	0	1	1
F-14	25.5844	0	0	0	1	0	0	0	1	1	0	1	1
F-15	9.449037	49.8	1	1	0	0	0	0	0	0	0	0	0
F-16	12.49385	56.4	1	1	0	0	0	0	0	0	0	0	0
Accuracy								**68.75%**	**81.25%**	**75%**	**68.75%**	**81.25%**	**75%**

Table 1. Validation table of Sporecaster models on the development of white mold disease incidence (DI%). Max Probability lists the maximum risk probability as derived from the predictive models during the flowering period (R1-R4) for each location. DI lists the percentage of plants that exhibited white mold at the time of scouting at the R6 growth stage. DI5 and DI10 indicate if the DI was either greater than 5% or 10%, where if DI > 5% then DI5 would equal 1, and DI < 5% then DI5 would be 0. Further, a binary variable was used to determine if the max probability was greater than different thresholds of 20%, 30%, or 40% during the flowering period. Finally, success/failure was determined if the DI and the risk thresholds were in agreement then a 1 was given, and if DI and risk thresholds were not in agreement, then a 0 was given. Finally, the percentage of each DI and threshold was calculated to determine the success accuracy across all locations.