IMPROVING WHITE MOLD MANAGEMENT OF SOYBEAN IN WISCONSIN

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Introduction

White mold (Sclerotinia stem rot) is caused by *Sclerotinia sclerotiorum* and consistently ranks in the top ten diseases plaguing global soybean crops (Wrather *et al.*, 2010). In 2009, United States soybean losses due to white mold reached almost 59 million bushels and cost growers a corresponding ~$560 million (Koenning & Wrather, 2010; Peltier *et al.*, 2012). Furthermore, according to a United Soybean Board report from 2011, white mold epidemics in the Great Lakes region alone were responsible for 94% of nationwide losses to the disease and cost regional growers ~$138 million (USDA-NASS 2015). White mold is infamously characterized by its challenging fungal promiscuity and longevity, and by the subsequently devastating crop losses; Wisconsin growers justifiably rank white mold management third in significance and concern.

Disease control is limited due to the lack of complete resistance in commercial cultivars (Peltier et al. 2012) and the often incomplete or limited success of chemical applications. Rigorous investigation of white mold resistant soybean germplasm for release to breeding programs would improve commercially available resistance. Additionally, improving our understanding of the complex timing and conditions surrounding white mold development would assist in providing effective fungicide recommendations. Product selection and application timing must both be considered for successful white mold management. Furthermore, risk assessment tools may be used to more accurately predict the timing of effective fungicide applications based on weather conditions, pathogen presence, and host architecture. An improved understanding of chemical control, development of resistant germplasm, and an optimized forecasting system would improve management strategies of white mold in soybean.

Research Objectives

1. Evaluate fungicide product efficacy and application timing for white mold control in Wisconsin.
2. Evaluate physiological resistance to white mold in soybean germplasm using a panel of representative *S. sclerotiorum* isolates.
3. Further investigate the roles of weather variables in the formation of apothecia in soybean crops. Use this information to develop and refine an improved advisory system for white mold in soybean.

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Methods and Results

Fungicide efficacy and timing

In 2016, 15 fungicide applications (including a non-treated control) were evaluated for white mold control in Hancock, Wisconsin (Table 2). Small plots were established in agricultural research station fields with a previous history of white mold; plots were irrigated to promote disease development. Products were applied at either the R1, R3, or both R1 and R3 growth stages. The disease incidence and disease severity index (DSI) was determined at the R6 growth stage and yield data were collected at harvest. The best treatments tended to include Aproach at 9 fl oz applied at R1 and R3 or Endura at 8 oz applied at R1. A combination treatment of Priaxor at 4 fl oz and Endura at 6 oz applied at R1 also resulted in comparably low disease levels and high yields.

Additionally in 2016, 16 fungicide treatment timings (including a non-treated) were evaluated for white mold control at the Hancock Agricultural Research Station (Table 1). Aproach at 9 fl oz, Endura at 8 oz, and Proline at 5 fl oz were applied at the R1, R3, R4, or R5 growth stages. DSI and DI data were collected at the R6 growth stage and yield data were collected at harvest. The best treatments were those where fungicide was applied at the R1 to R3 growth stages (or a combination of R1 and R3 applications). Endura at 8 oz applied at the R3 growth stage and Aproach at 9 fl oz applied at both R1 and R3 resulted in the lowest disease levels and the highest yields.

These results are similar to findings from corresponding trials in Michigan and Iowa. These data, therefore, have been incorporated into extensive fungicide evaluations conducted in the North Central region over the past 8 years. Overall, 26 site-years were analyzed, including data from Illinois, Iowa, Michigan, and Wisconsin, to determine the most efficacious products and timings for soybean white mold management.

White mold-resistant germplasm

Previously, resistant soybean germplasm was generated from crosses between highly resistant experimental lines (W04-1002 or AxN-1-55) and lines exhibiting good resistance to other diseases such as brown stem rot, soybean sudden death syndrome, and soybean cyst nematode. Over the last 3 years, germplasm lines have been rigorously evaluated in white mold nurseries under high disease pressure. In 2016, seven elite lines were selected and evaluated against seven other check lines or industry standard varieties. The trial was conducted at the Hancock Agricultural Research Station in small, irrigated plots. Disease (DSI and DI), lodging, and yield data, as well as oil and protein content, were collected and evaluated for all lines. Additionally, the seven elite lines were challenged with a panel of nine representative *S. sclerotiorum* isolates in greenhouse evaluations. Stem lesion development was monitored for 14 days post-inoculation and used to evaluate the durability of germplasm line resistance. Overall, greenhouse line performance against multiple isolates was evaluated against field performance of the same lines to determine the best resistant lines for release to breeding programs. Of particular interest, line 91-38 consistently performed well in greenhouse and field evaluations. In 2016, the line exhibited low disease levels (38.9 DSI, 14% DI), moderate yield (49.8 bu/a), minimal lodging (score of 1.0, upright), and high protein (38.6%) and oil (19.2%) content (relative to averages in the Great Lakes region). Line 91-38 has been selected for public release (2018 growing season) as a food-grade soybean variety.

Table 1. White mold ratings and yield of soybeans treated with various fungicides (2016).

Treatment and Rate/Acre (Crop Growth Stage at Application)	Disease Incidence (%)	Disease Severity Incidence (DSI)[z]	Yield (bu/a)
Aproach 9.0 fl oz (R1 + R3)	**3.7**	**20.8 cd[y]**	**82.5**
Endura 6 oz (R1) + Priaxor 4.0 fl oz (R3)	**3.5**	**17.0 cd**	**81.9**
Endura 8 oz (R1) - Positive Control	**3.9**	**20.3 cd**	**79.2**
Priaxor 4.0 fl oz (R1) + Endura 6.0 fl oz (R1)	**3.0**	**17.2 cd**	**78.5**
Domark 5 fl oz (R1)	6.2	33.6 abc	78.4
Domark 4 fl oz (R3)+ Topsin-M 0.75 lbs (R3)	3.0	21.4 cd	78.0
Priaxor 4.0 fl oz + Domark 4.0 fl oz (R1)	7.4	44.7 a	77.8
Endura 6 oz (R1)	3.6	18.9 cd	77.2
Domark 5 fl oz (R3)	6.9	30.3 abc	77.1
Topsin-M 0.75 lbs (R1)	2.6	16.1 cd	76.2
Non-treated control	6.9	32.2 abc	74.9
Domark 4 fl oz (R1)+ Topsin-M 0.75 lbs (R1)	7.1	35.3 abc	74.9
Cobra 6.0 fl oz (R1) + Endura 8.0 oz (R1)	2.7	13.6 bcd	72.9
Vida 0.5 fl oz + Domark 5 fl oz (R3)	1.4	7.8 d	72.1
Topsin-M 0.75 lbs (R3)	3.8	26.4 a-d	69.3
F-value	1.33	2.05	1.54
Pr>F	0.24	0.03	0.14

[z]Sclerotinia stem rot DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9.

[y]Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; α=0.05)

Table 2. White mold ratings and yield of soybeans treated with various fungicides applied at different growth stages (2016).

Treatment and Rate/Acre (Crop Growth Stage at Application)	DI (%)	DSI[z]	Yield (bu/a)
Aproach 9.0 fl oz (R1+R3) [Standard Check]	**10.2 de[y]**	**30.8 f**	**77.0 a**
Endura 8.0 oz (R3)	**6.8 e**	**20.2 g**	**75.3 ab**
Aproach 9.0 fl oz (R3)	15.0 b-d	45.2 de	72.5 abc
Endura 8.0 oz (R1) [Standard Check]	14.3 cd	37.1 ef	68.6 bcd
Proline 5.0 fl oz (R4)	21.0 abc	66.1 abc	68.5 bcd
Proline 5.0 fl oz (R3)	15.9 bcd	47.5 cde	66.4 cde
Aproach 9.0 fl oz (R5)	20.0 ac	49.1 be	66.0 c-f
Aproach 9.0 fl oz (R4)	25.3 ab	67.1 ab	62.9 d-g
Endura 6.0 oz (V5)	22.5 abc	51.9 be	61.7 e-g
Aproach 9.0 fl oz (V5)	24.2 abc	54.5 bcd	61.6 e-g
Non-Treated Control	25.6 ab	62.5 a-d	61.0 e-g
Endura 8.0 oz (R4)	32.1 a	77.0 a	60.8 e-g
Endura 8.0 oz (R5)	30.1 a	64.5 abc	60.3 e-g
Proline 5.0 fl oz (R1)	25.2 ab	66.3 abc	59.7 fg
Proline 5.0 fl oz (R5)	25.3 ab	56.9 a-d	59.0 g
Aproach 9.0 fl oz (R1)	33.0 a	68.2 ab	57.2 g
F- value	4.97	8.63	6.11
Pr>F	<0.01	<0.01	<0.01

[z]Sclerotinia stem rot DSI was generated by rating 30 arbitrarily selected plants in each plot and scoring plants with on a 0-3 scale: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. The scores of the 30 plants were totaled and divided by 0.9.
[y]Means followed by the same letter are not significantly different based on Fisher's Least Significant Difference (LSD; α=0.05)

White mold advisory development

Previously, a 3-variable model, considering site-specific (GPS referenced) air temperature, relative humidity, and wind speed, was developed to predict apothecial presence in soybean fields. In 2016, model validation was conducted at agricultural research stations in Wisconsin and Michigan. Small plots were scouted to monitor apothecial presence and rated to evaluate disease control. Additionally, apothecial presence and the resulting disease incidence was monitored in 20 Wisconsin grower fields to further evaluate model implementation. Grower field observations matched 89% of same day model predictions; furthermore, full-season model predictions explained 74% of overall disease observations. In addition to the development of a publically available advisory, this modeling exercise is helping to improve our understanding of the complex interaction of temperature and moisture required to make accurate white mold predictions. This understanding may also help us look at long-term forecasting in order to make disease predictions well in advance of an epidemic.

Additionally in 2016, we continued to monitor the growth and development of *S. sclerotiorum* and collected detailed data of the progression and severity of white mold disease in Wisconsin soybean fields. Virtually available weather data were used in a series of statistical models to predict disease development to generate potential models for spray advisory purposes. Based on multi-site validations of model performance, the existing model was refined to consider irrigation, row spacing, air temperature, relative humidity, and wind speed. Separate models were generated for irrigated and non-irrigated fields, using combinations of the remaining four variables, to predict the risk of infection by the white mold fungus. Continued validation of these models will occur in the 2017 field season.

Conclusions

Successful chemical control of white mold can be achieved using appropriately timed and efficacious fungicide applications. In Wisconsin studies, Endura at 8 oz applied at R1 and Aproach at 9 fl oz applied at R1 and R3 continue to be among the best programs for control. Furthermore, treatments applied at the R1 or R3 growth stages are more effective than those applied at the R4 or R5 growth stages. Fungicide application timing has been further investigated using a predictive advisory system. Virtually available weather data have been successfully used to predict the risk of apothecial presence in a field and, therefore, can be used to accurately and effectively time fungicide applications. Additionally, the predictive model can be improved by considering basic management practices such as row spacing and irrigation. The refined apothecial models will continue to be validated in future years in both research and grower locations. These studies have resulted in the preliminary development of publicly-accessible, site-specific advisory tool. Because chemical control of white mold can be incomplete, white mold-resistant soybean varieties will be a key component of an integrated white mold management program. Rigorously evaluated resistant soybean germplasm, therefore, should be used in the development of more resistant varieties that can eventually be integrated into improved white mold management systems. Overall, appropriate fungicide selection, effective timing of application, and incorporation of promising white mold resistance will improve existing management systems.

References

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