VIRGINIA SOYBEAN BOARD PROJECT REPORT – FY2014/2015

PROJECT TITLE: Validation, Optimization, and Deployment of Fungicide Advisories for Soybean

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OBJECTIVES:

1) Validate and optimize a weather-based disease advisory model for timing of foliar fungicide application in soybean
2) Evaluate profitability of different fungicide spray schedules based on yield response and input costs
3) Initiate development of a web-based disease advisory alert system for soybean

SUMMARY OF RESULTS:

Objective 1- Growth stage-based fungicide applications (R3, beginning pod) were compared to weather-based disease advisory applications at seven on-farm locations and two research stations in 2014. Yield response to fungicide applications was significant in four of the seven on-farm trials. When a yield response occurred, R3 stage applications were equal to or better than decision aid applications suggesting the R3 stage is the optimal time to apply fungicide. However, yield response to fungicide applications was greatest when weather conditions conducive to disease development occurred within 7 days of the R3 growth stage. Trials in 2014 suggest the R3 growth stage is the optimum time to apply foliar fungicide **if** favorable conditions for disease development occur within 7 days of the R3 stage. Additional years of data including a range of environmental conditions and more detailed assessments of crop and disease development are needed to further optimize and validate a weather-based decision aid for foliar fungicide applications in soybean.

Objective 2 – Based on a cost-benefit analysis of foliar fungicide applications, the yield response necessary to break even was calculated for different soybean prices. Based on 2014 trials evaluating fungicide application timings using a weather-based decision aid, applying a foliar fungicide when weather conditions are not conducive to disease development reduces the likelihood that a yield response necessary to cover application costs will be obtained, especially when the price for soybeans is under $11 per acre.

Objective 3 – More data is needed before a weather-based disease advisory system is implemented for soybean. However, results from trials in 2014 are promising and demonstrate the feasibility of predicting the profitability of foliar fungicide applications in soybean based on weather conditions conducive for disease development. In 2015, a preliminary advisory for soybean will be posted during the growing season on the "Virginia Ag Pest and Crop Advisory" (blogs.ext.vt.edu/ag-pest-advisory/).

RESULTS AND DISCUSSION:

Objective 1 - Validate and optimize a weather-based disease advisory model for timing of foliar fungicide application in soybean. In 2014, on-farm and small plot studies were conducted to validate and optimize weather-based parameters for determining timing of fungicide applications. Trials were successfully conducted at seven on-farm locations and at the Tidewater (Suffolk) and Eastern Virginia (Warsaw) Agricultural Research and Extension Centers (ARECs). The most commonly observed foliar diseases throughout Virginia were frogeye leaf spot (*Cercospora sojina*) and Cercospora blight (*C. kikuchii*). Weather stations at or near each location collected temperature and relative humidity (RH) data. Days with average temperatures between 65-78 ˚F and relative humidity >95% for 10 or more hours were considered "favorable days" for infection, disease development, and spread of foliar pathogens; the occurrence of these conditions was used to time "decision aid" or "advisory" fungicide applications. Small plot studies at the two AREC locations included calendar/growth-stage based fungicide applications and either one or two advisory fungicide applications (Tables 1, 2). At both locations, "favorable days" corresponded to the R3 growth stage and thus growth stage and weather-based applications were applied simultaneously. Weather conditions were favorable for disease development, and all fungicide timings between R3 and up to three weeks after R3 resulted in a yield increase compared to the untreated control. Yield response to fungicide application was statistically significant at the Warsaw location only, but the trend was similar at the two locations (Figure 1). Results suggest that when environmental conditions favor disease development at or near the R3 growth stage, fungicide applications are likely to increase yield.

Table 1. Effect of fungicide application timings on disease and yield response in soybean at the Tidewater AREC, 2014.

	% foliar disease (23 Sep)		% foliar disease[2] (6 Oct)	% defoliation[4]		Yield (bu/A)[5]
Treatment application timing/dates[1]	Upper canopy[2]	Lower canopy[3]		23 Sep	6 Oct	
Untreated	15.0 ab	18.0 ab	18.0 ab	12.0 a-c	77.0 a	62.3
1st spray @ R_3, beginning pod (8/10)	10.4 c	12.0 c	14.0 b-d	11.4 bc	57.0 b-d	67.4
1st spray @ R_3, beginning pod (8/10) 2nd spray @ R_3 + 21 days (9/2)	10.4 c	14.0 bc	12.0 cd	11.0 bc	42.0 e	63.6
1 advisory spray (8/10)	10.8 c	12.4 c	19.0 a	14.0 ab	49.0 c-e	65.3
Multiple advisory sprays (8/10, 8/28)	11.0 bc	12.8 c	13.0 cd	11.4 bc	40.0 e	64.9
1 spray 1 week after R_3 (8/21)	9.8 c	11.0 c	12.0 cd	9.4 c	47.0 c-e	64.0
1 spray 2 weeks after R_3 (8/26)	12.4 a-c	12.0 c	15.0 a-c	10.0 c	59.0 bc	66.0
1 spray 3 weeks after R_3 (9/2)	13.2 a-c	14.8 bc	14.0 b-d	14.0 ab	57.0 b-d	67.0
1 spray 4 weeks after R_3 (9/18)	16.0 a	20.0 a	12.0 cd	14.0 ab	70.0 ab	62.5
Weekly sprays between R_3 and R_5 (8/10, 8/26)	11.8 bc	11.8 c	10.0 d	12.0 a-c	44.0 de	69.3
Untreated	16.4 a	20.0 a	18.0 ab	15.0 a	81.0 a	61.3
***P*(F)**	**0.01**	**0.0008**	**0.0008**	**0.01**	**0.0001**	**0.15**

[1]Priaxor 4.17SC 4 fl oz/A. [2]Percent leaf area with foliar disease, primarily Cercospora blight. [3]Percent leaf area with foliar disease, primarily Septoria brown spot. [4]Percent canopy defoliated. [5]Yields are weight of soybeans with 13.5% moisture. One bushel equals 60 lb. Soybeans were harvested 19 Oct. Means in a column followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (*P*=0.05). Percentage data were arcsine transformed prior to statistical analysis.

Table 2. Effect of fungicide application timings on yield response in soybean at the Eastern Virginia AREC, 2014.

Treatment application timing/dates[1]	Yield (bu/A)[2]	Wt./100 seed (oz)	% purple seed stain[3]
Untreated	56.3 e	0.5 bc	3.4
1st spray @ R_3, beginning pod (7/25)	61.6 cd	0.5 ab	4.6
1st spray @ R_3, beginning pod (7/25) 2nd spray @ R_3 + 21 days (8/14)	68.2 a	0.6 a	4.6
1 advisory spray (7/25)	63.3 bc	0.5 a	5.0
Multiple advisory sprays (7/25, 8/14)	66.9 ab	0.6 a	3.2
1 spray 1 week after R_3 (8/6)	64.6 a-c	0.6 a	3.6
1 spray 2 weeks after R_3 (8/14)	61.0 cd	0.5 ab	3.6
1 spray 3 weeks after R_3 (8/20)	62.8 cd	0.5 ab	3.4
1 spray 4 weeks after R_3 (8/27)	59.0 de	0.5 a-c	3.8
Weekly sprays between R_3 and R_5 (7/25, 8/14, 8/27)	67.9 a	0.6 a	3.8
1 spray 5 weeks after R_3 (9/3)	56.5 e	0.5 c	3.2
***P*(F)**	**0.0001**	**0.005**	**0.23**

[1] Priaxor 4.17SC 4 fl oz/A. The major disease at this location was frogeye leaf spot (*Cercospora sojina*).

[2] Yields are weight of soybeans with 13.5% moisture. One bushel equals 60 lb. Soybeans were harvested 9 Oct.

[3] Data are percent of 100 seed with symptoms of disease.

Means in a column followed by the same letter(s) are not significantly different according to Fisher's Protected LSD (*P*=0.05).

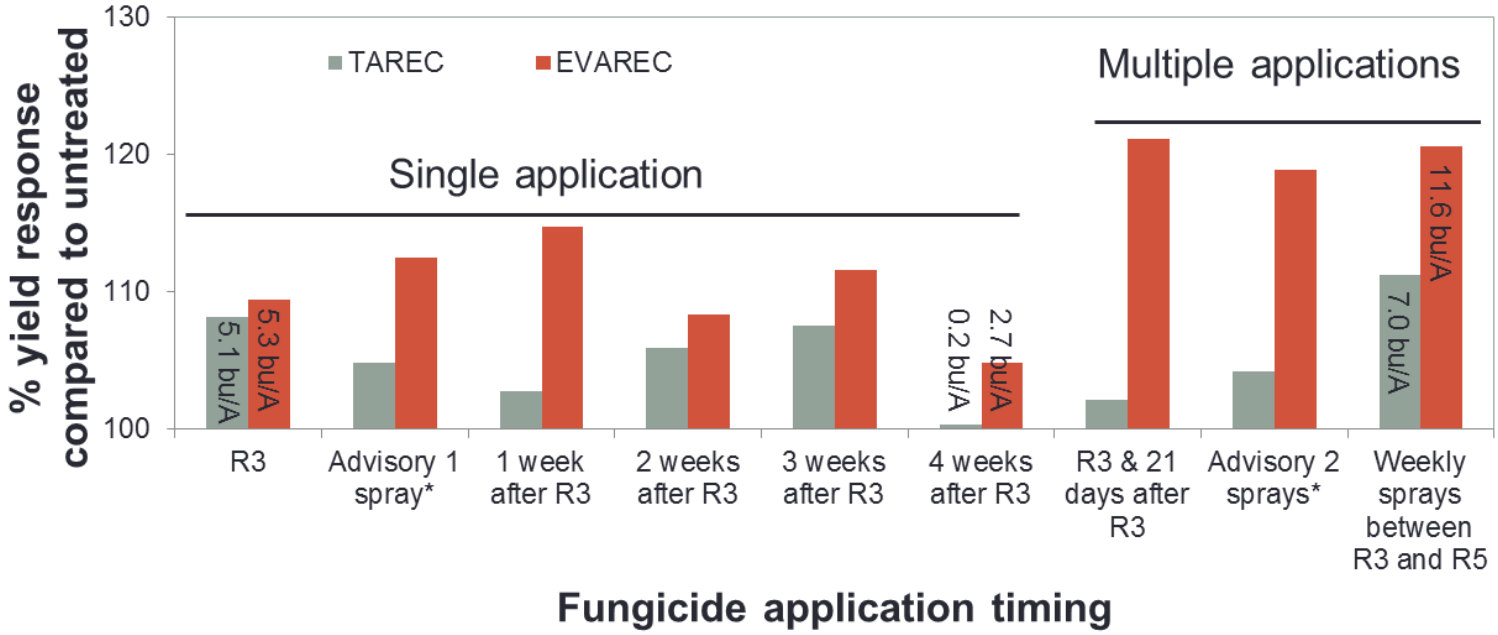

Figure 1. Soybean yield response to different application timings of Priaxor 4.17SC at 4 fl oz/A. Trials were conducted at the Tidewater AREC (TAREC, Suffolk) and Eastern Virginia AREC (EVAREC, Warsaw). Growth-stage based applications (R3, beginning pod) were compared to weather-based timings (advisory spray). Additional applications were made at weekly increments after the onset of the R3 growth stage. Weather-based parameters for triggering an advisory spray included two consecutive days of average temperatures between 65-78 ˚F and relative humidity >95% for 10 or more hours. At both locations, the advisory sprays were triggered on the same date that the growth-stage based applications were made. Yield response is expressed as a percentage compared to the untreated control. Each percent yield response above 100% represents a 0.6 bu/A yield increase compared to the untreated control. Numbers indicated for select treatments are the bu/A increase compared to the control. The dominant foliar diseases were Cercospora blight and frogeye leaf spot at the TAREC and EVAREC, respectively.

Weather conditions were more variable among the on-farm locations and thus these studies provided more insight into the utility of the weather-based advisory. Strip plots with three treatments in a randomized complete block design compared R3 and weather-based ("decision aid") fungicide applications to untreated controls (Table 3). A significant yield response to fungicide application was detected in four of the seven trials. R3 applications were equal to, or in one case better than, decision aid applications suggesting that if a fungicide application is needed, the R3 growth stage is the optimum time to apply the fungicide. However, the R3 applications did not always result in a yield increase compared to the untreated control. Data indicate that favorable conditions for disease development at or near the R3 growth stage increase the likelihood that fungicide applications will increase yield. The one exception was the Accomack location where symptoms of nematode damage and sudden death syndrome were observed throughout the field. This suggests impacts of soilborne pathogens on yield may negate any benefits of fungicide applications for control of foliar diseases.

The relationship between yield response and the number of days between the R3 growth stage and favorable days for disease is shown in Figure 2. Due to high levels of soilborne disease at the Accomack location that may have confounded the results, this location was excluded from the analysis in Figure 2. The greatest yield increases to fungicide applications were detected when favorable environmental conditions for disease occurred within 7 days of the R3 growth stage; yield did not increase when the favorable days occurred more than 10 days after R3. Though there was a significant linear relationship between proximity of "favorable days" to the R3 stage and yield response, this relationship may or may not hold up in other years. Weather conditions during non-favorable periods for disease development were unusually dry in many Virginia locations in 2014 and likely slowed down or halted disease development. In moderately wet years, disease development during non-optimal weather conditions and during later growth stages of the soybean crop may have the potential to impact yield. Thus, additional years of data are needed to verify the trends observed in 2014.

Results from 2014 suggest the R3 growth stage is likely the optimum time to apply fungicides but favorable environmental conditions for disease development must also occur within a week of the R3 growth stage for a significant yield increase to occur. A second year of data is required to validate the weather parameters, but results of the first year of this project demonstrate that it is possible to improve fungicide application recommendations based on weather variables.

Table 3. Results of 2014 on-farm trials for validation of a weather-based fungicide advisory for soybean.

County	Variety	Treatment	Spray Date	Fungicide & Rate	Yield (bu/A)[a]
Orange	Asgrow AG4633	Control	NA		47.4 B
		R3	July 29	Priaxor - 4 oz/A	52.6 A
		Decision Aid	Aug 4	Priaxor - 4 oz/A	52.0 A
Culpeper	NK S41-J6	Control	NA		61.0 A
		R3	Aug 11	Priaxor – 4 oz/A	59.7 A
		Decision Aid	Aug 20	Priaxor – 4 oz/A	57.2 A
Stafford	Pioneer P39T67	Control	NA		67.8 A
		R3	Aug 7	Quadris Top - 11 oz/A	69.7 A
		Decision Aid	Aug 16	Quadris Top - 11 oz/A	70.2 A
Amelia	Armor 5363	Control	NA		41.4 C
		R3	Aug 15	Quadris Top – 10 oz/A	47.7 A
		Decision Aid	Aug 20	Quadris Top – 10 oz/A	46.1 B
Nottoway		Control	NA		45.4 B
		R3	Sept 16		46.7 A
		Decision Aid	Sept 26		46.7 A
Sussex	Hubner H53-12R2	Control	NA		30.0 B
		R3	Sept 3	Stratego YLD – 6 oz/A	34.2 A
		Decision Aid	Sept 16	Stratego YLD – 6 oz/A	32.7 A
Accomack	Channel 4206 & 4306	Control	NA		54.7 A
		R3	Sept 11	Stratego YLD – 4 oz/A	53.6 A
		Decision Aid	Sept 15	Stratego YLD – 4 oz/A	48.8 A

[a]Yields followed by the same letter within a location are not significantly different at 90% confidence level

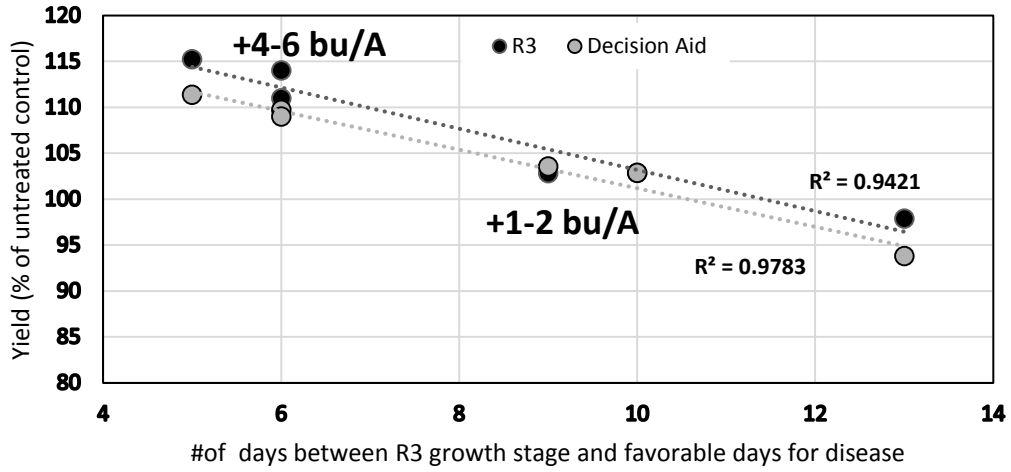

Figure 2. Relationship between favorable days for disease development and yield response to fungicide applications at either the R3 growth stage (R3) or when environmental conditions favor disease (decision aid). Yield response is expressed as a percentage of the untreated control (yield treated/yield untreated × 100%). The proximity of environmental conditions favoring disease development to the R3 growth stage is expressed as the number of days between R3 and "favorable days" based on data collected from weather stations near each location.

Objective 2 - Evaluate profitability of different fungicide spray schedules based on yield response and input costs. Based on a cost-benefit analysis of foliar fungicide applications, the yield response necessary to break even was calculated for different soybean prices (Table 4). Based on 2014 results of the weather-based advisory, applying a foliar fungicide when weather conditions are not conducive to disease development reduces the likelihood that a yield response necessary to cover application costs will be obtained, especially when the price for soybeans is under $11 per acre. Based on Figure 2, in 2014 a 4-6 bu/A yield increase occurred if weather conditions favorable for disease development occurred within a week of R3, but if conducive weather conditions occurred more than 8 days after the R3 growth stage, a 1-2 bu/A yield response or less was observed. Yield response values in Table 4 are shaded to indicate the treatment cost/soybean price combinations for which a yield response of 1-2 bu/A would be profitable. In contrast, a 4-6 bu/A yield response to fungicide application would be profitable for all treatment cost/soybean price combinations indicated in Table 4. This illustrates the utility of using a weather-based decision aid to decide whether or not to fungicide applications will be profitable in soybean, especially when crop prices are low.

Table 4. Yield response in bushels per acre required to break even with different treatment costs and prices received for the soybean crop.

Treatment cost/A	Soybean price/bu					
	$9	**$10**	**$11**	**$12**	**$13**	**$14**
$15.00	1.7	1.5	1.4	1.3	1.2	1.1
$17.50	1.9	1.8	1.6	1.5	1.3	1.3
$20.00	2.2	2.0	1.8	1.7	1.5	1.4
$22.50	2.5	2.3	2.0	1.9	1.7	1.6
$25.00	2.8	2.5	2.3	2.1	1.9	1.8
$27.50	3.1	2.8	2.5	2.3	2.1	2.0
$30.00	3.3	3.0	2.7	2.5	2.3	2.1
$32.50	3.6	3.3	3.0	2.7	2.5	2.3
$35.00	3.9	3.5	3.2	2.9	2.7	2.5

Objective 3 - Initiate development of a web-based disease advisory alert system for soybean. More data is needed before a weather-based disease advisory system is implemented for use by soybean growers. However, results of 2014 are promising and demonstrate the feasibility of predicting the profitability of foliar fungicide applications in soybean based on weather conditions conducive for disease development. In 2015, a preliminary advisory for soybean will be posted during the growing season on the "Virginia Ag Pest and Crop Advisory" (blogs.ext.vt.edu/ag-pest-advisory/). Options for obtaining weather data that will be used to generate the advisory are currently being explored. One promising option is a satellite-based weather service (ZedX Skybit) that can provide hourly weather data for $100-$200 per location per year. This will allow for weather data to be obtained from multiple locations throughout Virginia where soybean is grown at a potentially lower cost than installing and maintaining weather stations throughout the state.

CONCLUSIONS:

- On-farm trials in 2014 suggest fungicide applications are more likely to result in a significant yield response if favorable conditions for disease development occur within 7 days of the R3 stage.
- Fungicide applications made when weather conditions are favorable for disease development are likely to be profitable and result in a yield response that will offset and exceed fungicide application costs.
- Additional years of data including a range of environmental conditions and more detailed assessments of crop and disease development are needed to further validate and optimize a weather-based decision aid for foliar fungicide applications in soybean.