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Plant Pathology Fact Sheet

Soybean Yield Loss Prediction Tool for Managing Soybean Rust

by Joseph A. Omielan, *UK Department of Plant and Soil Sciences*,
Donald E. Hershman, *UK Department of Plant Pathology*,
and Saratha V. Kumudini, *Monsanto Company, Research Triangle Park, NC*

INTRODUCTION

Soybean rust (SBR), caused by the fungus, *Phakopsora pachyrhizi*, is a potentially devastating foliar disease of soybean. The disease was first detected in the Continental United States in the fall of 2004. Since that time, it has caused only sporadic yield losses in the U.S., primarily in the Gulf States. However, the potential still exists for devastating losses to occur in all soybean producing areas of the U.S. should the proper combination of weather conditions come together to support significant disease development by mid-summer. Currently, the only way to avert significant yield loss caused by SBR when disease risk is high is by applying foliar fungicides. For detailed information on the use of foliar fungicides, refer to *Using Foliar Fungicides to Manage Soybean Rust* (SR-2008) in the resource list.

State Extension plant pathologists formulate general SBR management recommendation based upon, 1) current distribution and severity of SBR, 2) range of local stages of soybean development, and 3) disease/weather forecasts. Heretofore, no tools have existed to help soybean producers make field-specific decisions about the need to spray. A SBR Yield Loss Prediction Tool [http://dept.ca.uky.edu/sbrtool/] was developed to address this need. The tool is intended to be used in conjunction with the more generalized state-wide or multi-county SBR risk assessments made by state Extension specialists.

The tool utilizes a model that weighs potential yield losses against the cost of fungicidal control in relation to the crop stage. The goal is to help producers make more informed SBR management decisions, ultimately improving economic returns and limiting the use of unnecessary fungicide applications. The SBR Yield Loss Tool and model were developed in collaboration with a number of scientists in the United States and Brazil. This publication provides information about how the tool was developed and its limitations. It will also serve to guide the user on its application.

Tool Development

The initial objective was to develop and validate a simple yield loss prediction model for SBR, based on the mechanism by which the disease reduces soybean yield. In a two-year study conducted in Brazil, SBR-induced yield loss was found to be due to: (i) accelerated leaf drop, (ii) reduced green leaf area (GLA) and (iii) reduced photosynthetic capacity of GLA. Yield reductions were greater the earlier in the crop's development SBR became established. To account for this, the three factors were integrated over time into a factor called Effective Leaf Area Duration (ELAD). Reduction in ELAD was a measure of the damage to the crop canopy caused by SBR and was determined to be a good predictor of yield loss. This is the basis of the yield loss model.

Next, independent studies were conducted to validate the accuracy of model predictions over a range of environments, cultivar maturity groups, and row widths in the U.S. Trials were planted in Quincy, FL in 2007, Tifton, GA in 2008, and southern Brazil in 2006 and 2009. The results are presented in Figure 1.

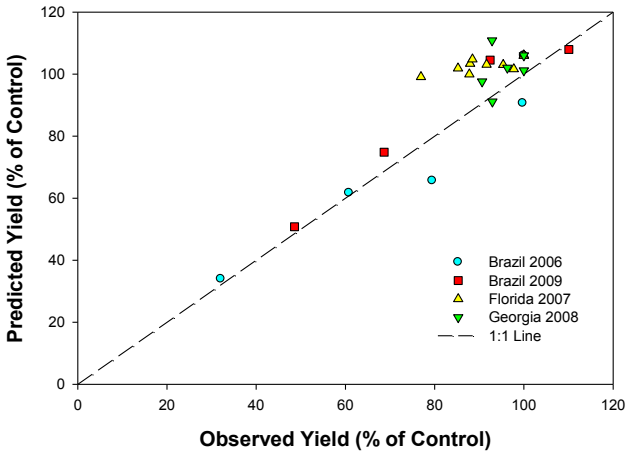

Figure 1. Observed vs. predicted yields for the validation trials.

The Brazil trials had severe SBR epidemics and large reductions in ELAD and yield. However, we have learned over the past five years that lesser SBR epidemics are much more common in the U.S. Consequently, reduced rates of disease progress (and associated yield loss damage) were estimated and incorporated into the model. The expanded model assumes that severe, moderate, and light SBR epidemics have rapid, moderate, and slow disease progress, respectively. The estimated yield losses were calculated for SBR starting at different growth stages and for different epidemic scenarios. These estimates were compared with actual research data from 47 U.S. and 39 Brazil fungicide trials. The yields from the unsprayed control plots were expressed as a percentage of the yields from the best fungicide treatment. In general, the yield estimates were within the range of yield outcomes from the fungicide trials (Figure 2). Significant variability in how estimated yield loss compared to actual yield achieved was anticipated due to the presence of many confounding factors in the tests.

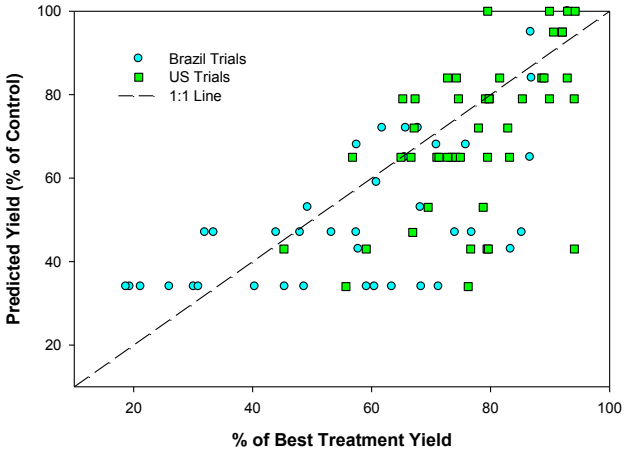

Figure 2. Percent of best treatment yields vs. predicted yields for U.S. and Brazil fungicide trial data.

Limitations of the Yield Loss Model

The SBR Yield Loss Prediction Tool uses a model to estimate yield loss that was developed using data generated in Brazil with severe SBR epidemics. Validation trials were conducted in the U.S. to test

how well the model estimated yield losses under a number of row widths, genotypes, and growing conditions. However, these only represent a small sampling of the genotypes, row widths, growing conditions, and management operations likely to occur in the U.S. The use of this model for prediction of relative yield loss across a wide range of soybean production systems must be taken with the understanding of these limitations. The tool is most amenable to use by southern soybean producers. It is unknown how useful it will be for northern production systems, but it may be. In addition, the scenarios for 'moderate' and 'light' epidemics are not based on independently validated data, but represent hypothetical scenarios, based on what is 'likely' to occur. Again, yield loss predictions based on the 'moderate' and 'light' epidemics must be taken with the understanding of these limitations.

Use of the Tool

Estimated yield losses have been combined with economic calculations on an interactive Soybean Rust Yield Loss Prediction Tool website to assist growers making fungicide spray decisions (Figure 3).

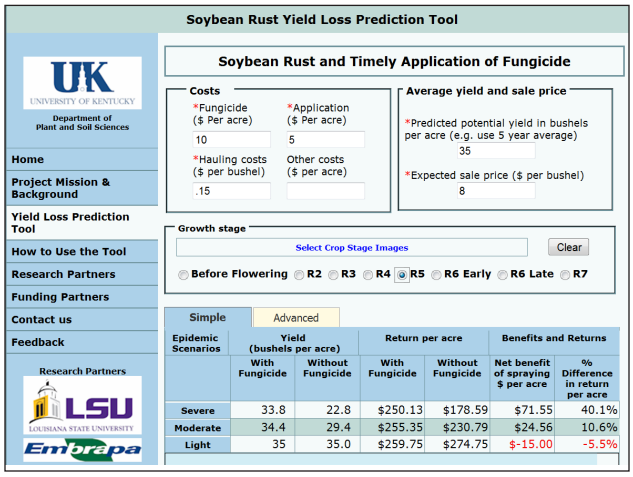

Figure 3. Screenshot of the SBR Yield Loss Prediction Tool website with example

The user will be asked to enter the following costs:

- Fungicide chemical ($ per acre)
- Fungicide application ($ per acre)
- Soybean hauling ($ per bushel)

as well as the following information:

- Predicted potential yield (bushel per acre) (suggested: use 5 year average)
- Expected sale price ($ per bushel)

Once the growth stage when SBR is first reported or expected is selected, the following calculations are performed.

Current assumptions: The assumption is that the best fungicides are about 90% effective for SBR control. Therefore, the yield with fungicide application will be reduced by 10% of the yield reduction if no control is applied (note that the yields for the severe and moderate epidemics are less than the predicted potential yield in Figure 3. The yield without fungicide is reduced as predicted by the model, from the potential yield. The calculations for the other fields are listed below.

- Return per acre with fungicide = (Expected Yield) X (Price per bushel – Hauling cost) – (Cost of fungicide + application)
- Return per acre without fungicide = (Yield without fungicide) X (Price per bushel – Hauling cost)
- Net Benefit of Spraying = (Return with fungicide) – (Return without fungicide)
- Percent Difference in Return = (Net benefit of spraying) ÷ (Return per acre with fungicide)

In addition to the table of results, there is a graphical output of the net benefit of spraying ($ per acre) for the three epidemic scenarios at different soybean prices (Figure 4). Fungicide application would be economically justified with a positive net benefit of spraying for the growth stage and anticipated SBR epidemic severity. Keep in

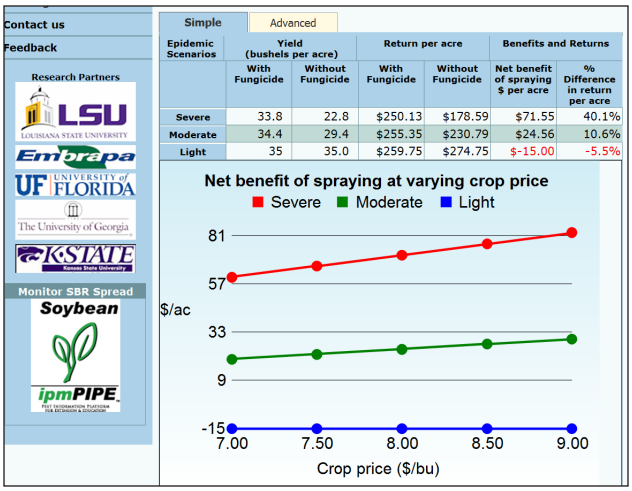

FIGURE 4. SCREENSHOT OF TOOL WEBSITE WITH GRAPH OUTPUT.

the mind the uncertainty of future weather and the resulting disease progress and damage, as well as the limitations of the yield loss model.

Severe: Sensitivity Analysis - Benefits of spraying at varying yield potentials

Soybean price ($/bu)	Yield potential without pest problem, (bu/ac) 25.00	30.00	35.00	40.00	45.00
	Net benefit of spraying, ($/ac)				
$7.00	$38.94	$49.73	$60.52	$71.31	$82.10
$7.50	$42.88	$54.46	$66.03	$77.61	$89.19
$8.00	$46.82	$59.18	$71.55	$83.91	$96.27
$8.50	$50.76	$63.91	$77.06	$90.21	$103.36
$9.00	$54.69	$68.63	$82.57	$96.51	$110.45

Fungicide cost ($/ac)	Yield potential without pest problem, (bu/ac) 25.00	30.00	35.00	40.00	45.00	Breakeven Yield, (bu/ac)
	Net benefit of spraying, ($/ac)					
$5.00	$51.82	$64.18	$76.55	$88.91	$101.27	1.27
$7.50	$49.32	$61.68	$74.05	$86.41	$98.77	1.59
$10.00	$46.82	$59.18	$71.55	$83.91	$96.27	1.91
$12.50	$44.32	$56.68	$69.05	$81.41	$93.77	2.23
$15.00	$41.82	$54.18	$66.55	$78.91	$91.27	2.55

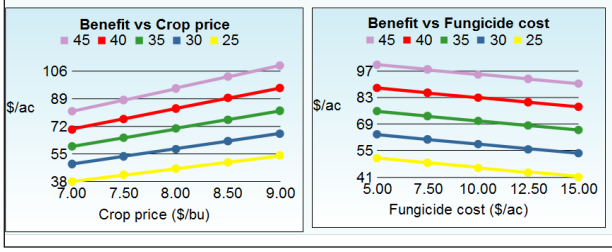

FIGURE 5. SCREENSHOT OF SENSITIVITY ANALYSIS. VALUES INPUT WERE 35 BUSHELS PER ACRE FOR YIELD POTENTIAL, $8 PER BUSHEL FOR SOYBEAN PRICE, AND $25 PER ACRE FOR FUNGICIDE CHEMICAL COST.

There are additional calculations available through the "Advanced" tab on the Tool page. There may be uncertainty in this year's yield potential, soybean prices, and/or fungicide costs which may affect whether or not it is economical to spray. The net benefit of spraying is calculated for higher and lower values than those entered by the user as "Sensitivity Analyses" for each of the Epidemic Scenarios. In the example shown in Figure 5, the benefit of spraying is negative with yield potentials and soybean prices lower than those input into the tool. Price uncertainty is part of risk management. Hopefully, this tool will help you manage your risk of SBR yield loss with an informed decision.

RESOURCES

- Soybean Rust Yield Loss Prediction Tool website (University of Kentucky et al.) http://dept.ca.uky.edu/sbrtool/

- Using Foliar Fungicides to Manage Soybean Rust, SR-2008 (University of Kentucky, et al. 2007) *available at County Extension offices, as well as on the Internet* http://oardc.osu.edu/soyrust/

- Kentucky Soybean Rust Information Web site (University of Kentucky) http://www.uky.edu/soybeanrust

- National Soybean Rust Web site (IPM Pest Information Platform for Extension and Education) http://www.sbrusa.net

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