The Development and Validation of a Simple Yield Loss Prediction Model for Soybean Rust

Joe Omielan, Abdullah Aqeel, Elena Prior, Jim Board, Cláudia Godoy, David Wright, Bob Kemerait, Weibo Dong, and Saratha Kumudini

RESULTS: Model Development (Brazil)

In a two year study conducted in Brazil, SBR-induced yield losses were found to be due to: (i) accelerated leaf drop, (ii) reduced green leaf area (GLA) and (iii) reduced photosynthetic capacity of GLA. The reduced photosynthetic capacity of GLA has been quantified in controlled environment and field experiments (Kumudini et al., 2008a,b). Our understanding of these factors was used to develop the model.

OBJECTIVES

The objectives were to:
1) develop a simple yield loss prediction model for soybean rust, based on the mechanism by which the disease reduces yield.
2) validate this model with independent data sets.

METHODOLOGY (Pt 1)

Model Development (Brazil): The Effective Leaf Area Index (ELAI) is a calculated value of the leaf area that is effective in contributing to photosynthesis and thereby yield (Jesus Junior et al., 2003). The calculation of ELAI takes all three factors that affect SBR-induced yield loss into consideration.

The ELAI is calculated as follows: ELAI = LAI(1-x-x), where x is the proportion of diseased tissue and i is the Bastiaans coefficient. The disease severity from the trial (Fig. 1) was used to calculate the ELAI for the control and SBR treatments, using a Bastiaans coefficient of 3. The impact of the disease on ELAI must incorporate the temporal aspect of SBR damage. This is achieved by integrating ELAI over time (R5 to R7) to get Effective Leaf Area Duration (ELAD).

ELAD = ∫[0 to ∞] ELAI dt = ∫[0 to ∞] LAI(1-x-x) dt

where n is the number of assessments, ELAI is the ELAI at time i and (ti+1 − ti) is the interval (days) between two consecutive assessments.

ELAD as % of control was plotted against yield as % of control (Table 1 and Figure 3). The linear relationship (R² = 0.82) is the basis of the yield loss model (Eq. 1).

RESULTS: Model Validation (Florida)

The independent data set from Brazil (2008) affirmed the fit of the yield loss equation (Table 4). The data from the Brazil 2007 trial and Georgia 2008 trial were used to validate the model. The observed vs. predicted yield values were plotted against the predicted values (Fig. 9). This process represented a more stringent test of the model's ability to predict yield losses in a model's independent data set. We decided that the ELAI-R7 data from the 2007 Brazil trial would be used as the independent data set.

The yield loss equation was calculated to predict % yield loss from the % ELAD data for each of the trials. The observed yield values were plotted against the predicted values (Fig. 10). The relationship between ELAD and yield loss was found to be linear (R² = 0.93). The equation for predicting yield loss was

% ELAD = % Yield loss

Figure 6. Relationship between effective leaf area duration (integrated from R5 to R7) and yield loss (% of control) for 2007/2008 Florida trial.

SUMMARY

Data from Brazil was used to develop a simple yield loss prediction model using the relationship between proportional decreases in ELAI and proportional decreases in yield. Validation from the U.S. in this independent data set, if the control LAI and SBR treatments remain at the range of disease severity observed in the Brazil trial, would confirm the applicability of the model to U.S. soybean rust management practices.