Meta-analysis of the linear relationship between soybean yield loss and rust severity from uniform fungicide trials

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INTRODUCTION

Since 2003/04 season the management of soybean rust using foliar fungicides has been evaluated in uniform field trials (UFTs) across Brazil. To effectively combine and interpret large and variable datasets, like those in the UFTs, biologically relevant questions must be explored using appropriate statistical methods to enable proper interpretation. Our objectives were to: (i) assess the relationship between disease severity and yield to select trials suitable for the analysis (ii) summarize the nature of yield loss-severity relationships via meta-analysis modeling.

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MATERIAL AND METHODS

Fungicide trials data

Eighty-one (81) trials were conducted in Brazil from 2003/04 to 2007/08 growing seasons, across 25 locations from southern to northern Brazil. A range of fungicide treatments were evaluated. Plot disease rust severity at R6 and plot yield (kg/ha) during harvest were measured.

Trial selection criteria

Examination on raw data: trials where maximum severity <25% were excluded. Statistical criteria for trial selection were:

1) Linear regression *between soybean yield (Y) and rust severity (X) was used to check adequacy of the linear model in each trial. Trials were excluded based on the lack of high evidence of linear relationship between Y and X (b1-p-value> 0.10).*

2) Influence measures *(DFB) were calculated to quantify changes in intercept (b_0) and slope (b_1) of the linear model, in each trial. DFB_b0 and DFB_b1 were calculated for each observation. Trials for which maximum DFB_b0 or maximum DFB_b1 were higher than two were excluded.*

Modeling yield loss-rust severity relationship

Soybean yield loss in each treatment was calculated as estimated soybean yield in the absence of rust (intercept). From these estimates, linear regression models without intercept were fitted to describe the relationship between yield loss and rust severity in each trial. The estimated change in yield loss as consequence of a unitary increase on rust severity and the random error associated were estimated for each trial.

Meta-analysis of effect sizes

A random effects mixed model was used to calculate mean effect sizes (mean slopes) assuming them to represent a random sample.

Moderator variables of the slopes

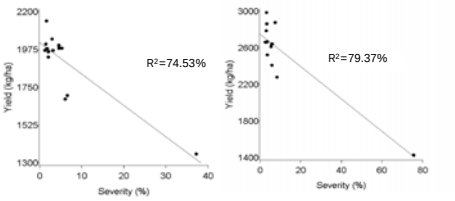
(I) state; (ii) year; (iii) rust severity class (<50%; >50%)
(iv) cultivar maturity class (others or late maturity)
(v) disease onset timing (before R3 or after R3)
(vi) soybean yield (<2000 kg/ha, 2000-4000 kg/ha or >4000kg/ha).

RESULTS

- Eight trials were excluded due to SBR severity below the defined threshold. Thirty-four (34) trials were excluded based on statistical criteria for linear model performance (30 due to influential point and 4 due to p-values were greater than 0.1).

- Influential observations were noted from trials in which check treatments (i.e., no fungicide application) had high disease severity associated with low yields and low severity for most fungicide treatments that varied in yield (Fig. 1).

Fig. 1: Examples of two trials for which determination coefficient (R^2) and p-value for slope indicate high goodness of fit, but influence analysis shows presence of leverage points.



- In the 39 selected trials, R^2 ranged from 0.24 to 0.91 (median= 0.74). There was considerable variation observed for the maximum estimated yield (1435 to 5252 kg/ha, Fig 2A), in contrast with low variation for the slope estimates of linear relationship (-4.8 to -5.6 kg/ha.pp, Fig. 2B).

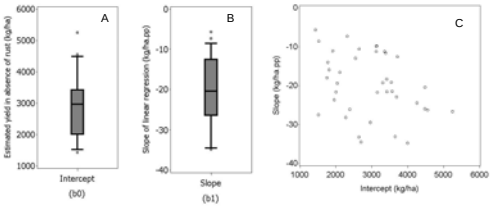
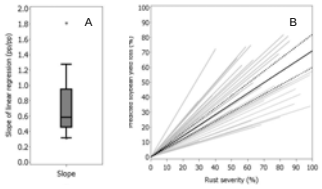


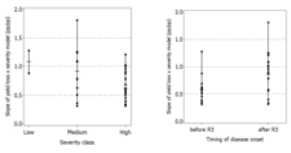
Fig. 2. Box-plots of estimated intercepts (b0) and slopes (b1) of linear regression models fitted for describing the relationship between soybean yield and rust severity (A, B). Relationship between estimated intercepts and slopes(C) (n=39 trials),

- Estimated change in yield loss (percent point, pp) as consequence of a unitary increase on rust severity ranged from 0.31 to 1.94 (Fig. 4). Median and weighted mean of the estimated slope were 0.58 and 0.71, respectively.

Fig. 3. Between trial variability for estimated slopes of the soybean yield loss versus rust severity linear models (39 selected trials); (A) box-plots and (B) fitted models for each trial pooled model with 95% confidence bands, estimated via meta analysis.



Residual between-study variance (no covariates): 0.1633. Reduction in variance for severity class (18%) and disease onset (17%). Other variables (year or state) did not reduce variance



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