

Relationship between soybean plant defoliation and Asian soybean rust severity

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ABSTRACT

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Data from experiments conducted in the field with eight fungicide mixtures added of five mancozeb levels were used to generate gradients of soybean rust severity, plant defoliation, and soybean grain yield. The data were subjected to correlation analysis between defoliation and severity, defoliation and grain yield, and grain yield and rust severity. All correlations were significant, evidencing a

relationship between variables. Analyses conducted in other studies have shown that severity control has greater influence on decision-making, compared to defoliation. Therefore, as defoliation is dependent on severity, evaluation of rust intensity is sufficient, suggesting that defoliation can be excluded from evaluation for this pathosystem.

Keywords: rust intensity, *Glycine max*, *Phakopsora pachyrhizi*, healthy leaf area, grain yield

RESUMO

Reis, E.M.; Zanatta, M.; Reis, A.C. Relação entre a desfolha de plantas de soja e a severidade da ferrugem. *Summa Phytopathologica*, v.45, n.3, p.252-254, 2019.

Com os dados de experimentos conduzidos no campo com oito misturas de fungicidas adicionadas de cinco doses de mancozebe foram gerados gradientes da severidade da ferrugem da soja, da desfolha das plantas e do rendimento de grãos. Os dados foram submetidos a análise de correlação entre a desfolha e a severidade, entre a desfolha e o rendimento de grãos e entre o rendimento de grãos e a severidade. Todas

as correlações foram significativas comprovando a dependência entre as variáveis analisadas. Na análise de outras pesquisas os dados do controle da severidade pesam mais na tomada de decisão do que a desfolha. Pode-se, portanto, concluir que como a desfolha é dependente da severidade é suficiente a sua avaliação, sugerindo-se que desfolha pode ser dispensada de avaliação nesse patossistema.

Palavras-chave: Intensidade ferrugem, *Glycine max*, *Phakopsora pachyrhizi*, área foliar sadia, rendimento de grãos.

Soybean growing area in Brazil reached 33.7 million hectares in the 2016/17 growing season (4).

Asian soybean rust (ASR), caused by the fungus *Phakopsora pachyrhizi* Sydow & Sydow, was reported in South America in 2001 (13) and is considered the most destructive disease affecting soybean [*Glycine max* (L.) Merr.] crop (3).

In the literature, there are numerous studies on the damage caused by ASR but no report on the methodology used for its quantification in order to establish the relationship between different disease intensities and the resulting damage. Using a scientific methodology, Danelli et al. (6) generated a function to estimate the damage caused by soybean rust according to the disease intensity at any growth stage: $Y = 1,000 - 5.84(4.53 - 9.02) LI$ (where y = grain yield normalized to 1,000 kg/ha; LI = central leaflet incidence of leaves inserted in the main stem). This function can also be used for timing the first fungicide application considering the principles of integrated disease management (14). Fungicide application with the aim of reducing the damage caused by ASR has been the main control strategy.

The symptoms/signs of ASR are numerous leaf lesions containing several individual uredia. A striking feature of ASR is early defoliation of soybean plants due to destruction of the healthy leaf area by rust severity. In general, high severity is required to start early defoliation. ASR leaflet incidence increases very rapid. After detection of <10%

incidence in central leaflets inserted in the main stem, it can reach 100% in 35 to 43 days, and lesion density can increase from 9.6 to 23.3/cm² over a period of 25 to 30 days (5), followed by plant defoliation.

Considering the high demand for evaluating ASR severity and defoliation, scales have been developed to train monitors on how to estimate these variables in soybean plots (8, 11).

The hypothesis of this study was that defoliation is a function of ASR severity, requires time-consuming evaluation and has not or has been little considered in the decision-making for the choice of the fungicide type and level, number of applications and intervals between applications. Only severity control has been considered for fungicide performance. In the literature, there is no study on the use of defoliation as a criterion to choose the best fungicide, its level, or interval between its applications.

Therefore, the aim of this study was to show whether there is a relationship between ASR severity and defoliation in soybean plants.

MATERIAL AND METHODS

Several field experiments were carried out in the 2015/16 growing season in Passo Fundo County, Rio Grande do Sul State (17), Brazil, with different fungicide treatment programs ($n = 43$). The results of

these experiments and the effects on rust severity, control, grain yield, and plant defoliation resulting from rust attack were analyzed to verify whether there is a relationship between ASR leaflet severity and plant defoliation.

Defoliation was evaluated by assigning a relative percentage to plots, considering 'zero' for undefoliated plots and 100% for plots showing total defoliation, similarly to the scale of Hirano et al. (11).

Disease severity was estimated according to the diagrammatic scale of ASR proposed by Godoy et al. (8). Only the central leaflets of leaves with petioles inserted in the main stem of five plants per plot were detached and assessed.

Severity data (independent variable) were related to defoliation (dependent variable). The relationships between grain yield and defoliation and between grain yield and severity were also determined.

RESULTS AND DISCUSSION

The relationship between foliolar severity of soybean rust and defoliation was represented by the functions: exponential $S = 6.347e^{0.0234D}$ and $R^2 = 0.9004$ or linear $S = 0.6189D - 6.3056$, and $R^2 = 0.794$, where 'S' is the foliolar rust severity and 'D' is the plant defoliation (Fig. 1).

Yang et al. (19) also obtained a negative relationship between plant defoliation and soybean rust severity ($y = 2.387 + 0.686x$ in a cultivar and $y = 4.20 + 0.758x$ in another cultivar).

Soybean defoliation can be greatly influenced by the environment, even under constant severity (18). Thus, the resulting damage can vary from site to site or from season to season.

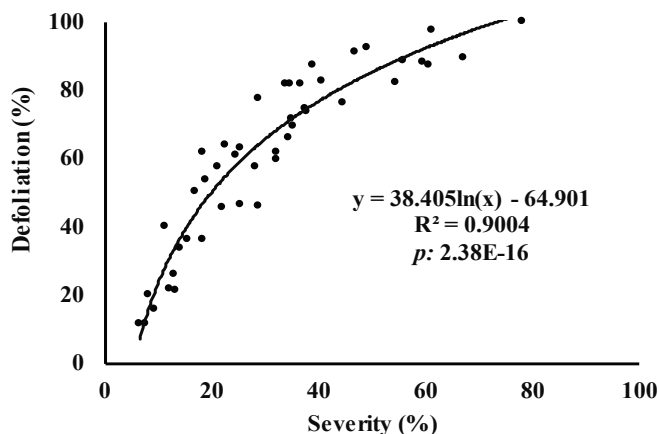


Figure 1. Positive relationship between soybean plant defoliation and rust severity caused by *Phakopsora pachyrhizi* (y – defoliation; x – disease severity; R^2 – coefficient of determination; \ln - logarithm) ($n = 43$).

As foliar rust severity increased, defoliation increased, showing a coefficient of determination of 0.9004. Therefore, the relationship between these two factors is sufficient to assess leaf severity.

Higgledy (10) demonstrated that there was a linear relationship between yield and damage and reduction in canopy after soybean defoliation, as shown in our study (Fig. 2).

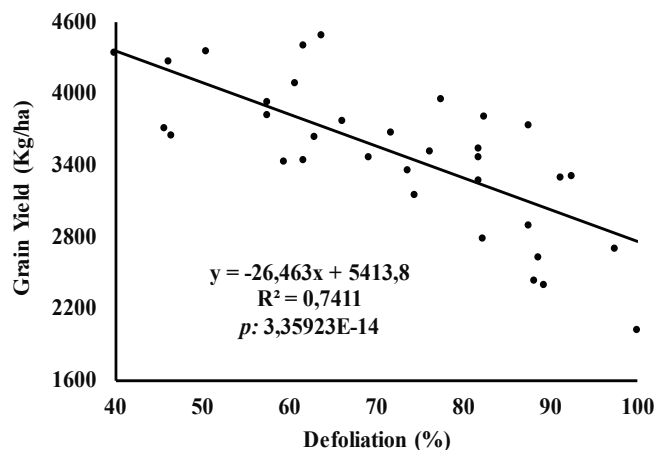


Figure 2. Negative relationship between grain yield and defoliation of soybean plants due to rust caused by *Phakopsora pachyrhizi* ($n = 43$).

The first ASR infections occur in the lower, older leaves; the disease accelerates leaf abscission from the lower canopy layers and reduces healthy green leaf area duration due to necrotic lesions, which limits the yield by reducing the plant ability to intercept and absorb solar radiation (12).

The reproductive phase of soybean plants is the most sensitive stage for defoliation, and leaf drop during this phase may affect soybean yield and its components (7).

Haile et al. (9) found that high levels of defoliation (about 55%) at R2 growth stage reduced both leaf area index (LAI) and yield and that damage was directly related to the reduction in LAI. Board et al. (1) reported that 100% defoliation at the beginning of R6 growth stage resulted in a 40% yield reduction, but the yield damage was only 20% considering defoliation three weeks after the beginning of R6 growth stage. In a more recent study, Board et al. (2) reported that soybean yield damage occurred when defoliation was severe enough to reduce LAI by 18 to 23%.

Leaf abscission is generally correlated with the number of rust lesions per leaflets (4). In a study performed in southern Brazil, Reis et al. (16) showed that lesion number/cm² leaflet area, considering the mean of several cultivars, was 10.5 on the adaxial surface and 15.3 on the abaxial side. The maximum number was 200/cm² and each lesion contained up to 16 uredia.

However, despite the correlation between defoliation and disease severity, defoliation may not be as useful as disease severity to predict yield reduction caused by ASR.

A negative relationship between soybean grain yield and foliolar rust severity was represented by the linear function $y = 5103.4 \text{ kg / ha} - 41.455 x$, and $R^2 = 0.8776$. Thus, for each 1% severity, yield was reduced by 41.455 kg/ha, considering a maximum yield of 5103.4 kg/ha (Fig. 3).

The relationship between grain yield and rust severity ($R^2 = 0.9776$) was more precise than the relationship between grain yield and defoliation ($R^2 = 0.7411$). The mathematical function of the relationship between yield and severity ($y = 5103.4 - 41.457x$, Fig. 3) can be used to calculate rust severity, which corresponds to a loss (R\$/ha) that is equal to the fungicide application cost, according to the criterion of the economic damage threshold (5, 13).

Therefore, once the relationship between soybean defoliation and

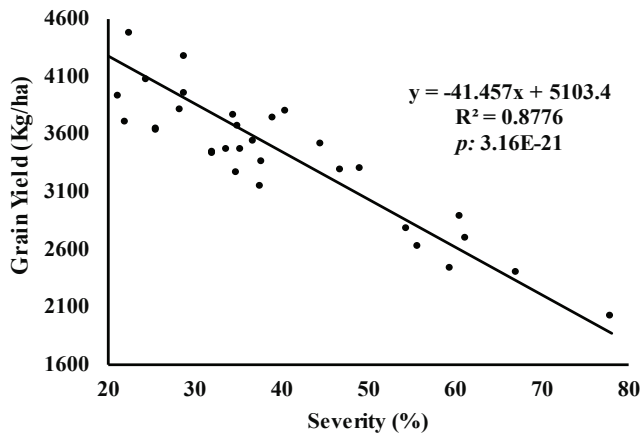


Figure 3. Negative relationship between soybean grain yield and foliolar rust severity caused by *Phakopsora pachyrhizi* (n = 43).

rust severity was shown, our hypothesis that the two variables are correlated was confirmed, and duplication of defoliation and severity assessments is not justifiable.

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