

Simulated Soybean Rust Infections Through Manual Defoliation: Yield and Quality Effects.

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ABSTRACT

Asian soybean rust (*Phakopsora pachyrhizi*) has the potential to cause enormous production losses in South America and poses an unknown but potentially significant threat to soybean [*Glycine max* (L.) Merr.] production in the US. However, little is known about how this pathogen might impact the indeterminate soybean varieties produced in major soybean production ranges of the US. Soybean plants were defoliated to simulate several soybean rust infections scenarios in seven environments in Minnesota, Michigan, Illinois, and Indiana to examine potential yield impacts of the disease. While significant treatment by environment interactions were found, some common responses were noted. Defoliation of the lower one third of canopies at R2 and R4, and defoliation of two thirds at R2 did not affect yields. Defoliation of the lower two thirds of canopies at R4 and R6 tended to have large and significant yield effects. Yield effects from defoliation of the upper portions of canopies from R2 through R6 were quite mixed. A better understanding of relative importance of various strata of soybean leaves across developmental time to soybean yield formation will help refine management recommendations for soybean rust in indeterminate soybean varieties.

MATERIALS AND METHODS

This experiment was established at seven locations in 2005 and 2006. Due to late harvests in several locations, this poster will present data from four of seven locations studied in 2006. Locations included St. Paul, Lambertson, and Rochester, MN, Urbana and Monmouth, IL, East Lansing, MI, and West Lafayette, IN. Experiments were planted in early May at all locations, and were planted in four row (0.76 m) plots that ranged from 3.0 to 7.3 m in length. Normal seeding rates of 63 to 73 seeds ha⁻¹ were employed at all locations.

Treatments consisted of leaf removal at three reproductive stages. Lower canopy leaf removal was intended to simulate defoliation induced by soybean rust infections. The level of defoliation simulated timing of protective fungicides, post-infection. At all locations, either one third or two thirds of the canopy was removed during early, middle or late reproductive growth (approximately R2, R4, and R5.5). Partial removal was calculated at the time of defoliation by removing one third or two thirds of the leaves, by count, from the lower portion of the canopy. At selected locations, upper portions of the canopy were also defoliated to simulate canopies where continued vegetative growth produced new leaves post-application of protective fungicides, leaving upper leaves vulnerable to new rust infections. In MI and MN ('06) leaves from the upper one third of the canopy were removed at two or three stages between R2 and R5.5. At Urbana, the upper one half of the canopy was removed at R4 or R6. At the three MN ('05) locations, new leaves formed since R1 were removed at R2 and R3 and new leaves formed since R4 were removed at R5 and R6. These defoliations represented only two to four leaves removed.

Defoliations were performed by hand in MN and IN, and mechanically in IL and MI. A rotary "weed whacker" with a plastic blade attachment was used in IL, and a "hedge trimmer" was used in MI. In each case plants were checked and remaining leaves were removed by hand. Upper defoliation treatments in MI were performed by hand.

Timing of lower canopy defoliations differed slightly. At Monmouth, IL and all MN ('05) defoliations occurred at R1, R3, and R5. In MI ('05 and '06), IN, and MN ('06) defoliations occurred at R2, R4, and R5.5. At Urbana these occurred at R2, R4, and R6.

RESULTS

When analyzed across environments, significant (at P≤0.05) environment by treatment interactions were identified. Attempts to divide locations by year or state did not remove this interaction. Therefore results will be presented by individual environment only.

Results of Lower Defoliation Treatments

- Lower 1/3 @ R1-2 affected yield in 2 of 11 environments
- Lower 2/3 @ R1-2 affected yield in 3 of 11 environments
- Lower 1/3 @ R3-4 affected yield in 3 of 11 environments
- Lower 2/3 @ R3-4 affected yield in 9 of 11 environments
- Lower 1/3 @ R5-6 affected yield in 5 of 11 environments
- Lower 2/3 @ R5-6 affected yield in 8 of 10 environments
- 2/3 defoliation treatments tended to reduce yields to a greater extent than 1/3 defoliation treatments.
- Later defoliation treatments (R5-6) tended to reduce yields more than earlier defoliation treatments.

Results from Upper Defoliation Treatments

- Across three environments in Minnesota ('06) where the upper 1/3 of canopies were removed at R3, R5, or R5.5-6, only one treatment in one environment affected yield (R5 at St. Paul).
- In Minnesota ('05) later removal of upper leaves affected yields in St Paul, while earlier removal of upper leaves affected yields at Rochester and Lambertson.
- At E. Lansing, in both '05 and '06, defoliation of the upper canopy at R3-4 had as great of an effect on yield as any other defoliation treatment in this study.
- At Urbana, IL, where upper defoliation treatments consisted of defoliation of 1/2 of the canopy, only these treatments affected yield.
- Canopies were fully defoliated in four environments. These resulted in an average yield loss of 1.65 Mg ha⁻¹ (or a 46% yield reduction).

DISCUSSION

Up to about 10% yield losses were noted in lower canopy 1/3 defoliation treatments, while 2/3 treatments showed yield losses up to about 30%. These yield losses tended to follow National Crop Insurance Services defoliation estimates quite closely (NCIS, 2003). Only in the E. Lansing environments ('05 and '06) were upper defoliation treatments found to affect yield to a greater extent than analogous lower canopy treatments.

Relative to soybean rust, these results indicate that indeterminate soybean is relatively tolerant of defoliation during reproductive development. Yield losses of greater than 1 Mg ha⁻¹ were not uncommon in late reproductive stage defoliations where 2/3 of the canopy was removed, however. Rust infections confined to the lower 1/3 of canopies during early reproductive development are unlikely to reduce yields significantly. Protection of newly developing leaves in the upper canopy may be important in certain environments; however, this study indicates that a large number of leaves must be lost to incur significant yield loss. This study simulated only the affect of leaf removal from rust infections. Deleterious effects beyond these (i.e. parasitic effects and/or effects on vasculature, pods or seeds) were not included and would tend to amplify treatment effects noted here.

REFERENCE

National Crop Insurance Services. 2003. Soybean loss instructions. NCIS Review 6302, National Crop Insurance Services, Inc. Overland Park, KS.

TREATMENT CODES

Lower 1/3 (2/3) @ R1-2 > removal of lower 1/3 (2/3) of leaves

- R2 at Urbana IL, W. Lafayette, IN, E. Lansing, MI, ('05 and '06), and all MN ('06)
- R1 at Monmouth, IL, all MN ('05)

Lower 1/3 (2/3) @ R3-4 > removal of lower 1/3 (2/3) of leaves

- R4 at Urbana IL, W. Lafayette, IN, E. Lansing, MI, ('05 and '06), and all MN ('06)
- R3 at Monmouth, IL, all MN ('05)

Lower 1/3 (2/3) @ R5-6 > removal of lower 1/3 (2/3) of leaves

- R6 at Urbana, IL
- R5.5 W. Lafayette, IN, E. Lansing, MI, ('05 and '06), and all MN ('06)
- R5 at Monmouth, IL, all MN ('05)

Upper 1/3 @ Rⁿx^m > removal of upper 1/3 of leaves at R stage noted

- R4 and R5.5 at E. Lansing ('05)
- R3 and R5 at E. Lansing ('06)
- R3, R5, and R6 at St. Paul and Rochester, MN ('06)
- R3, R5, and R5.5 at Lambertson, MN ('06)

Upper 1/2 @ Rⁿx^m > removal of upper 1/2 of leaves at R stage noted

- At Urbana, IL

New leaves since R1 @ Rⁿx^m > removal of any new leaves formed since R1 at stage indicated

- All MN ('06)

New leaves since R3 @ Rⁿx^m > removal of any new leaves formed since R3 at stage indicated

- All MN ('06)

Entire @ R5.5 > removal of all leaves at R stage noted

- W. Lafayette, IN, and all MN ('06)

