**Defoliation Soybean Response to Priaxor Application**

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**Abstract**

The objective of this greenhouse study is to determine plant response to Priaxor fungicide application after simulated hail injury (cut-off/broken stem, stem bent at 135-degree angle or defoliation loss of leaves) at the R2 and R5 soybean stages. Priaxor (4 fl oz/a) was applied three days post plant injury. The foliar fungicide applied at R2 or R5 stages did not increase seed yield of defoliated or non-defoliated soybean plants. Also, plant maturity was not affected by the fungicide application. Across fungicide treatments (untreated check and Priaxor) and growth stages, plant maturity and yield was similar between the untreated check and 33% defoliation. Seed yield declined 19 to 32% with 66% defoliation, cut stem or bent stem treatments compared to the untreated check. Also, plant maturity was delayed 5 to 11 days with 66% defoliation, cut stem or bent stem treatments compared to the untreated check.

**Introduction**

After hail, soybean (Glycine max) farmers may choose to mitigate the ripped leaf and broken plant carnage with a fungicide application. These fungicides are marketed tri-fold: a disease control, a disease preventer, and a plant health boost against stress.

In terms of disease control, field trials with soybean response to simulated or actual hail have not had to deal with a subsequent outbreak to fungal disease (Johnson and Peterson 2004; Fehr et al. 2008; Endres 2017). We have observed commercial soybean fields decimated by white mold (*Sclerotinia sclerotiorum* (Lib.) deBary) infection after hail, but these fields have been the minority instead of the majority (L. Lubenow, personal communication).

Dryland soybeans grown in North Dakota do not have high, fungal pressure under normal growing circumstances. Farmers only choose to add a fungicide after hail injury. In Carrington REC trials which solely look at fungicide efficacy, economic advantage from fungicides only occurs in irrigated trials under high, disease inoculum-added situations (Markell, 2011).

In terms of plant health, Priaxor (fluxapyroxad and pyraclostrobin) is a common plant health fungicide recommended agronomists after hail (L. Berg, personal communication). Farmers observe darker shades of green soybean plants as an indication that the fungicide is mitigating the hail injury. However, do plant health fungicides increase soybean yield production? Carrington REC studies showed no differences in yield with Priaxor applied after hail in 2011, and a higher yield with Headline (pyraclostrobin) application in 2016 but not in 2011 (Endres 2017).

Field studies on hail have shown plant stage and type of damage are important factors in yield loss. Loss of soybean cotyledons after unifoliate leaves have expanded produces no yield loss (Coulter and Nafziger 2008) while 100 percent leaf defoliation at R1 returned an eight percent yield loss (Johnson and Peterson 2004). At R4 and R5 plant stages, loss of leaves caused greater yield loss than partially broken plants (Fehr et al. 1983). Contrastingly, completely broken cut-off hail injury to soybean plants caused yield loss regardless of plant stage (Coulter and Nafziger 2008; Fehr et al. 1983).

The objective of this study is to determine plant response after simulated hail to Priaxor fungicide application with different types of defoliation (cut-off/broken stem, stem bent at 135-degree angle or defoliation loss of leaves) at the R2 and R5 soybean stages.

**Methodology**

A greenhouse study was conducted at the Carrington Research Extension Center, Carrington ND. The soybean cultivar was AG009X8. Seeds were planted in 10-inch pots with Miracle-Gro Moisture Control potting soil and 1-g of peat-based soybean inoculant on January 14, 2019. Light conditions were 16:8 light to darkness with light length gradually decreasing to 14 hours.

The study design was a randomized complete block design with split-split plot arrangement with three reps. The whole plot was Priaxor fungicide (+/-), the subplot was crop stage (R2 and R5), and sub-subplot was simulated hail injury (no damage, 33% leaf removal, 66% leaf removal, main stem cut-off, and main stem bent over).

* Untreated checks: no defoliation and no fungicide.
* 33% leaf removal: counted all leaves and removed 33% of leaves starting top to bottom of the plant.
* 66% leaf removal: counted all leaves and removed off 66% of leaves started top to bottom of the plant.
* Main stem cut-off: cut the main stem at the position that would remove half of the trifoliate notes on the main stem. 100% of the leaves were removed below the cut.
* Main stem bent over: the main stem was bent over at 135-degree angle at the same point as the cut-off treatment. One hundred percent of leaves were removed below the break and 25% of leaves were removed on the bent over portion of the stem.

All treatments were done by cutting off trifoliate leaves with a scissors. R2 damage was done on March 13 and R5 on March 25. Priaxor was applied three days post injury at a rate of 4 oz/a with a handheld boom backpack sprayer.

Plant greenness (signifying chlorophyll content) and canopy cover was measured for three subsequent dates after fungicide application. R2 treated-soybeans were measured 9, 16, and 23 days after fungicide treatment (DAT) and 11, 18, and 26 DAT for R5 damaged beans. Canopy coverage percentile was recorded using the Canopeo phone app (Oklahoma State University, Google Play). Greenness was measured as SPAD value representing total chlorophyll using a Minolta SPAD-502 chlorophyll meter (Konica-Minolta, Ramsey, NJ). For greenness value methodology, three separate trifoliate leaf readings were taken on each plant and the maximum green value was selected for data recording.

Physiological maturity was recorded and seed hand-harvested on June 6. Seed weight and maturity data was analyzed for differences at P≤0.05 and P≤0.1 levels using SAS software (SAS Institute Inc., Cary, NC). Greenness and Canopeo data for R2 and R5 data sets were analyzed as separate data sets for each observation reading using a split-plot randomized complete block experiment design with fungicide as the main plot and simulated hail injury as the subplot. [You must have done additional analysis?]

**Results**

The statistical analysis of this study showed no yield differences between fungicide and no fungicide treatments. Soybeans damaged at the R5 stage had lower yield than soybeans at the R2 stage (P=0.0434, df=1) (Table 1). Seed yield was less than the control when plants were injured by 66% leaf removal, bent-stems with 25% leaves removed or cut-off stems with leaves removed (P=0.0110, df=4) (Table 2).

Table 1. Mean seed weight (g) for simulated hail damage across all defoliation levels and fungicide (+/-).

|  |  |  |  |
| --- | --- | --- | --- |
| Stage | Seed Weight | | |
|  | grams | | % change |
| R2 | 9.04 | | 0 |
| R5 | 7.26 | | -22 |
| LSD (0.05) | | 1.6 |  |

Both, fungicide treated plants and no fungicide treated plants took 140 days until maturity. However overall, plants were slower to mature after receiving cut-off damage or 66% leaf removal, 10.7 and 6.6 days later respectively, than the control (P=0.866, df=4) (Table 3). Soybean plants withstood 33% leaf removal or having bent stems without a delay in maturity.

Table 2. Mean seed weight (g) for simulated hail defoliation levels across R2 and R5 stages & fungicide (+/-).

|  |  |  |  |
| --- | --- | --- | --- |
| Damage | Seed Weight | | |
|  | grams |  | % change |
| Control | 9.44 | ab | 0 |
| 33% Leaf Removal | 9.59 | a | +2 |
| 66% Leaf Removal | 7.61 | bc | -19 |
| Bent Stem | 7.54 | c | -20 |
| Cut-off Stem | 6.44 | c | -32 |
| LSD (0.05)= | 1.9 |  |  |

Table 3. Mean maturity for soybeans with simulated hail damage across R2 and R5 stages & fungicide (+/-).

|  |  |  |
| --- | --- | --- |
| Damage | Days to Mature | |
| Control | 119.9 | a |
| 33% Leaf Removal | 124.4 | ab |
| 66% Leaf Removal | 126.5 | bc |
| Bent Stem | 125.3 | abc |
| Cut-off Stem | 130.6 | c |
| LSD (0.05)= | 6.2 |  |

At R2/nine days after fungicide application, chlorophyll readings were significantly different for fungicide application (+/-) (P=0.0640, df=1) and type of simulated hail injury (P=0.0554, df=4). Greener plants were found nine days after Priaxor fungicide application (Table 4). Additionally at this 9 DAT timing, cut-off plants and 66% leaf removal plants had more greater SPAD values than the control (Table 5).

Table 5. Mean SPAD value (chlorophyll content) for R2 soybean plants with simulated hail injury across fungicide (+/-).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | SPAD Value | | | |
|  | Days After Fungicide Treatment | | | |
|  | 9 |  | 16 | 26 |
|  | (chlorophyll content) | | | |
| Control | 40.5 | a | 40.2 | 39.5 |
| 33% Leaf Removal | 42.5 | a | 41.6 | 40.9 |
| 66% Leaf Removal | 40.2 | ab | 41.0 | 43.2 |
| Bent Stem | 42.6 | a | 39.8 | 40.8 |
| Cut-off Stem | 37.3 | b | 39.5 | 41.0 |
| LSD (0.10)= | 3.17 |  | NS | NS |

Table 4. Mean SPAD value (chlorophyll content) for R2 soybean plants with fungicide and no fungicide across simulated hail damage variables.

|  |  |  |  |
| --- | --- | --- | --- |
|  | SPAD Value | | |
|  | Days After Fungicide Treatment | | |
|  | 9 | 16 | 26 |
|  | (chlorophyll content) | | |
| Priaxor (4 oz/a) | 41.2 | 41.3 | 41.3 |
| No Fungicide | 40.0 | 39.6 | 40.8 |
| LSD (0.10)= | 0.09 | NS | NS |

At the R5 stage during the first observation timing of 11 DAT, a significant interaction occurred between fungicide and simulated hail injury (P=0.0885, df=4). Cut-off stem injured, no-fungicide plants were less green than the no-fungicide control while every type of simulated hail injury with fungicide was less green that the fungicide control (Table 6). The addition of fungicide did not change the plant greenness at each specific hail injury level, for example bent stem with no fungicide and bent stem with fungicide application have statistically equivalent greenness values.

Canopeo canopy estimation was significant at all three observation times for R2 and R5 (data not shown). However, we are not confident in this app to estimate crop canopy in a single ceramic pot for several reasons. Photos taken under different lighting conditions variably estimated crop cover percentage (one to 30 percent) for a single pot. Also, we did not select a standard camera height to take the pictures from which gave us variable sq. ft. areas instead of a baseline uniform sq. ft. area (Figure 1).

Table 6. Mean SPAD value (chlorophyll content) for R5 soybeans plants with fungicide (+/-) whole plot and simulated hail damage subplots.

|  |  |  |
| --- | --- | --- |
|  | Fungicide | |
|  | Control | Priaxor (4 oz/a) |
|  | (chlorophyll content) | |
| Control | 40.1 | 42.2 |
| 33% Leaf Removal | 38.9 | 37.5 |
| 66% Leaf Removal | 40.5 | 36.6 |
| Bent Stem | 36.6 | 37.5 |
| Cut-off Stem | 34.9 | 36.6 |
| LSD (0.10) for whole plot means (down columns) = 4.5 | | |
| LSD (0.10) for whole plot means at the same or different subplot (across rows) = 6.2 | | |



Figure 1. Nonuniform R2 Canopeo photos.

**Discussion**

Priaxor fungicide did not increase seed yield. We expected this result based on Carrington REC field studies (Endres 2017). Priaxor-treated plants showed more greenness at R2 than non-fungicide plants nine days after fungicide treatment. This result validates farmer sentiments that the plants look greener after fungicide application. But, this greenness goes away over time. At R5, a flash of greenness happening right away did not occur. There are some differences in greenness: non-fungicide simulated hail-damaged plants were generally paler green than the non-fungicide control plants. But greenness was not recovered when comparing a specific hail injury treatment with a similarly-injured plant treated with fungicide.

Perhaps, farmers are applying Priaxor with the belief, it will protect their soybean crop from white mold infections. Certainly after hail, the dead tissue can catch in the leaf axils and be the perfect place for white mold spores to germinate and burrow into the soybean stem. However, Priaxor is shown to be poorly effective on white mold (Wunsch 2019) so a different fungicide should be utilized.

**Conclusion**

In conclusion, this study indicates the application of Priaxor after hail injury does not increase yield or extend plant maturity. Priaxor may green up R2 plants, but this effect is short-term.

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