ISA Final Contract Research Progress Report

Project Title: Further defining foliar fungicide use on soybean

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**Progress report (max 5000 characters)**

We completed field experiments at seven ISU Research Farms across Iowa near Crawfordsville, Nashua, Kanawha, Sutherland, Armstrong, McNay, and Ames each year. We compared 12-16 fungicides representing different chemistries and Fungicide resistance action committee (FRAC) code each year. Fungicide treatments included newly registered fungicides and/or new ways of applying existing fungicides. They were applied at different times during the growing season mainly in-furrow, V6, R1-R5 including double application of some fungicide combinations. An untreated control was included in all the locations for comparison. Major fungicides applied were Aproach, Aproach Prima, Custodia, Fortix, Preemptor, Priaxor, Quadris, Quadris Top, Quilt Xcel, Regalia, Stratego YLD, SkyRaider, Topguard EQ, Trivapro, Zolera FX. Insecticides alone and combination of insecticides and fungicides were compared in addition to fungicide in 2014 and 2015. Fungicides and insecticides rates were mainly based on company recommendations. Plots were 4 - 6 rows wide at 30-inch spacing and 25 to 40 ft long.

We assessed all foliar diseases present between R5-R6 soybean growth stages. We measured height of Septoria brown spot (SBS) in the plant canopy and rated other foliar disease severity on 10-20 leaves from upper canopy across all locations. Septorial brown spot, frogeye leaf spot, Cercospora leaf blight, and bacterial leaf blight were mainly observed across the locations in all years. Overall, SBS was number one disease in all the locations and years. In 2016, SBS was on the top leaves in most cases, perhaps from the excessive rainfall during the reproductive growth stages that favored the upward movement of Septoria. Frogeye leaf spot was more severe in 2016 compared to the previous years. The leaf area covered by frogeye was about 4 to 5% in untreated control pots in 2016 in Armstrong and McNay; all fungicide treatment plots has significantly lower severity than the UTC. No insect pests, including soybean aphid were observed above threshold level in any years and locations.

We also collected notes on delayed maturity, which was either “stay green” or “green stem disorder.” GSD was not a major problem in 2014. In 2014, the southwestern location had greater than 10% GSD. Fungicide treatments did not significantly increase GSD compared to the untreated control (UTC) in any location during 2014. At Sutherland in 2015, the azoxystrobin + propiconozole fungicide had higher levels of GSD compared to the UTC. There was comparatively higher severity of GSD at Nashua, McNay; however, fungicide effect was not significant in 2016. Data were and will be shared with ISA On-Farm Network after complete data are received.

We are establishing fungicide resistance management plan for soybean pathogens in Iowa. We are working with the Plant and Insect Diagnostic Clinic to do routine fungicide resistance screening in Iowa. We isolated several *Cercospora sojina* isolates from leaves with frogeye leaf spot from all trials across Iowa treated with a QoI fungicide. These isolates are being screened in the lab for fungicide resistance in 2015 and 2016. To date, we have not found any fungicide-resistant isolates in Iowa, but we are continuously working on screening for resistance isolates coordinating with plant diagnostic clinic.

A frogeye susceptible cultivar was planted in multiple farms in 2015 and 2016. Priaxor® (4 oz/A) sprays were applied at R1, R3, R5, 400 hours or 700 hours of RH > 85% beginning July 1 to determine how weather and application time relates to foliar fungicide response in 2015. RH data from ‘mesonet.agron.iastate.edu/request/download.phtm’ were used to determine threshold values, which were verified from on-site Spectrum sensors. Treatment did not affect seed moisture. Although the R1 spray showed the greatest reduction of foliar diseases, the R3 spray increased yield more than any other timings in 2015. Yield for the R3.5 and R4 treatments were about 7 bushels/A greater than the untreated control. There was no clear consistent correlation between disease control and wetness hours. In 2016, no statistical differences among the spray timings were observed for yield in any locations.

Farmer cooperators in Sigourney, Harper, Osceola, Radcliffe, and Lohrsville conducted replicated trials (N=4) of R3 foliar applications: 1) Priaxor® + Fasctac (4 oz & 3.2 oz/ac), 2) Priaxor® (4 oz), 3) no spray control. Disease ratings were obtained from specified GPS locations within each field. We collected aerial images of cooperator farms before the fungicide application and took disease data to correlate with these data.

**Final project results (Layman’s terms for all audiences) (limit 20000 characters)**

Septorial brown spot, frogeye leaf spot, Cercospora leaf blight, and bacterial leaf blight were mainly observed across the locations but at very low levels. Overall, Septoria brown spot was the most frequent disease at all locations and years. We measured height of brown spot disease in plant canopy, it moved to top leaves in most cases in UTC in 2016, perhaps due to the rainfall during the reproductive growth stages favoring the upward movement of Septoria. However, the severity was not at a level to cause yield loss. Septoria brown spot (SBS) progression in the canopy (height) was lower than the untreated control for several fungicides across many locations indicating fungicide spray reduced the SBS progress.

Yield response to fungicide treatments was very minimal and inconsistent, averaging -0.4 bu/A in 2014. In 2015, responses were mixed; nothing consistent was observed across all locations. There were both negative and positive responses to various treatments at some locations, but nothing consistent was observed over the seven locations. The average yield response for all R3 applied fungicides across all locations was 2.1 bushels/acre in 2015. In 2016, the average yield response to fungicide treatments were positive in all the locations ranged from 0.29 bushels/acre to 4.4 bushels/a across the locations, however the difference was not statistically different at *P* = 0.10. Although yield increases can occur sometime with foliar fungicide and/or insecticide treatments, current market prices and application costs may limit profitability when disease and/or insect pressure is low. For the most part, fungicides had minimal effect on moisture.

Priaxor® (4 oz/A) sprays were applied at R1, R3, R5, 400 hours or 700 hours of RH > 85% beginning July 1 to determine how weather and application time relates to foliar fungicide response. Although the R1 spray showed the greatest reduction of foliar diseases, yield response to the fungicide was better at R3 spray than any other timings. Yield for the R3.5 and R4 treatments were about 7 bushels/A greater than the untreated control in 2015. There was no clear consistent correlation between disease control and wetness hours. In 2016, no difference was observed among the spray timings for yield.

Establishment of fungicide resistant plan in Iowa is ongoing in coordinating with Plant and Insect Diagnostic Clinic. In 2015 and 2016, we isolated several *Cercospora sojina* isolates from leaves with frogeye leaf symptoms from all trials across Iowa treated with a strobilurin fungicide to screen for fungicide resistance. We have not found fungicide resistant isolates yet to report in Iowa but we are still testing the 2016 isolates. The protocol for screening isolates for resistance more quickly has been worked out for future years.

**Benefit so soybean farmers (limit 5000 characters)**

The result from this study will have directly benefited soybean farmers in Iowa and neighboring states and also establishes foundation to address future research and management questions.

Foliar diseases was not yield limiting in Iowa soybeans during the years of this project. Yield response to foliar fungicide spray was not very high in soybean unless there is very high disease severity. Our analysis of data collected over multiple years and locations indicates that fungicide and insecticide applications can sometimes increase soybean yield even in the absence of disease, which may be due, in part, to physiological changes that can sometimes occur in the plant. However, these applications were profitable less than 50% of the time of the time, based on average soybean market prices and application costs.

There was higher GSD incidence in southern Iowa locations than other parts of the state. Fungicides slightly increased GSD compared to untreated control. At the Sutherland location in 2015, the azoxystrobin + propiconozole fungicide had higher levels of GSD compared to the UTC. Soybean farmers should be aware of the added possibility that foliar fungicide applications may increase GSD incidence especially if plants experience a sink limiting stress.

We have not found fungicide resistant isolates in Iowa yet but we are continuously working on screening for resistance isolates coordinating with plant diagnostic clinic.

**Performances matrics (limit 4000 characters)**

We published a manuscript summarizing data from this study and from other similar studies done in the North Central Region.

Kandel, Y. R., Mueller, D. S., Bestor, N. R. C., Bradley, C. A., Giesler, L. J., Wise, K. A., 2016. Analyses of yield and net economic response from foliar fungicide and insecticide applications to soybean in the North Central United States. Plant health Progress. 17:232-238. doi:10.1094 / PHP-RS-16-0038

We included the findings from this study in several winter meetings and talks, we have presented information about fungicides through the ISU ICM News, newsletters and Extension presentations. Media interviews have been and will continue to be done. Data has been and will be added to the NCERA 137 Soybean Fungicide Efficacy table.

Research results have been published in farm progress reports every year. For example, please follow the link for farm progress 2015 report <http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1025&context=farmprogressreports>

A manuscript summarizing GSD data from 2014 and 2015 is near submission. It will be submitted soon in the Agronomy journal.

We are analyzing data and working on a manuscript using meta-analysis to better understand fungicides role under different weather conditions, disease severities etc. we will submit a manuscript in a peer-reviewed journal at the end of 2017.

We are summarizing last three years of data from 7 locations in the statewide fungicide trial. Our goal is to compare our dataset with ISA’s On-Farm Network’s fungicide dataset. Data analysis is ongoing and we also working on a manuscript comparing ISU small-plot and ISA on-farm trials on multiple aspects. Manuscript will be submitted in a peer-reviewed journal in a couple months.

Extra.

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| Table 1. Yield and Septoria brown spot (SBS) in the lower canopy in response to fungicide timings and placements in 2014. |
| Treatment | Yield bu/A | SBS % severity |
| Control | 63.8 c | 3.6 a |
| In-furrow Priaxor™ | 65.5 bc | 3.4 a |
| V6 Priaxor™ | 66.0 ab | 2.1 b |
| R3 Priaxor™ | 67.9 a | 2.6 b |
| *P*-value | 0.02 | 0.00 |
| CV | 4.56 | 25.89 |
| LSD | 2.08 | 0.53 |

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| Table 2. Effect of single foliar spray timing on yield and Septoria brown spot and the wetness periods of previous week in a replicated trial (N=6) at Bass Farm (Pioneer 92Y53).  |
| Time of single Priaxor spray  | Date | YieldBushels/A | Septoria Brown spot\*\* | Number of hours RH >86% of previous 7 days |
|  | 7-July  |  |  | 154 |
| R2 | 14-Jul\* | 64.9 | 1.9b | 165 |
|  | 21-Jul |  |  | 166 |
|  | 28-Jul  |  |  | 131 |
| R3 | 29-Jul\* | 66.9 | 2.3 ab |  |
|  | 4 -Aug |  |  | 48 |
|  | 11-Aug |  |  | 20 |
| R4 | 12-Aug\* | 67.6 | 2.4 ab |  |
|  | 18-Aug  |  |  | 19 |
| R5 | 19-Aug\* | 66.1 | 2.2 b |  |
|  | 25-Aug |  |  | 15 |
| R6 | 27-Aug\* | 62.2 | 3.3 a |  |
|  | 1-Sep |  |  | 34 |
| R7 | 7-Sep\* | 67.9 | 2.8 ab | 110 |
|  | 14-Sep |  |  | 146 |
| No spray |  | 66.4 | 2.8 ab |  |
| \*Dates are a single spray date \*\*Values in column with same letter do not differ (P<0.05). |

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| Table 3. Effect of fungicide treatments on yield (bushels/A) across seven Iowa locations in 2015  |
| Fungicide  | Stagea | Rate  | Ames | Armstrong | Crawfordsville | Kanawah | McNay | Nashua | Sutherland |
| Untreated control | --- | --- | 72.3 | 67.1 | 62.6 | 65.6 | 78.3 | 73.7 | 64.0 |
| Aproach | R3 | 6 | 74.2 | 68.9 | 66.1 | 65.8 | 77.9 | 77.8 | 64.5 |
| Aproach | R3 | 9 | 79.1\* | 64.5 | 65.3 | 65.6 | 76.8 | 76.9 | 63.9 |
| Priaxor | R3 | 4 | 78.2\* | 66.9 | 65.5 | 69.0 | 79.4 | 77.1 | 64.8 |
| Quilt Xcel | R3 | 10.5 | 77.1\* | 67.8 | 66.3 | 64.5 | 80.9 | 78.1 | 66.9\* |
| Stratego YLD | R3 | 4 | 75.8 | 68.0 | 66.3 | 68.7 | 79.2 | 78.0 | 64.8 |
| Stratego YLD + Leverage | R3 | 4 + 2.8 | 80.1\* | 67.8 | 63.6 | 70.4 | 81.5 | 74.8 | 64.7 |
| Aproach Prima | R3 | 8 | 77.2 | 66.0 | 67.0\* | 68.5 | 78.8 | 78.8\* | 65.8 |
| Quadris Top | R3 | 8 | 75.3 | 68.3 | 67.4\* | 68.0 | 83.7\* | 79.3\* | 65.4 |
| Fortix | R3 | 5 | 74.4 | 66.8 | 66.4 | 67.2 | 78.5 | 78.1 | 64.9 |
| Trivapro (Quilt Xcel + Solatenol) | R3 | 10.5 + 4.1 | 78.7\* | 64.2 | 66.3 | 65.5 | 81.2\* | 78.0 | 64.7 |
| Custodia | R3 | 8.6 | 77.7\* | 69.5 | 64.2 | 67.4 | 80.4 | 75.6 | 67.2\* |
| Quadris  | R3 | 6 | 72.5 | 69.1 | 63.5 | 67.8 | 82.6\* | 74.7 | 64.8 |
| Topguard | R3 | 5 | 76.8\* | 64.8 | 64.7 | 68.0 | 75.6 | 76.1 | 62.6 |
| Fortix | R1 | 5 | 64.5\* | --- | 62.5 | 66.8 | 80.3 | 73.6 | --- |
| Proline 480 SC (R1) + Stratego YLD (R3) | R1+R3 | 3 + 4 | 75.3 | --- | 66.1 | 66.2 | 83.1\* | 77.8 | --- |
| P value |   |   | 0.16 | 0.08 | 0.76 | 0.86 | 0.05 | 0.76 | 0.45 |
| CV |  |  | 4.83 | 3.80 | 5.56 | 6.09 | 4.08 | 5.56 | 3.56 |
| LSD (P<0.1) |   |   | 4.48 | 3.04 | 4.31 | 4.86 | 3.87 | 5.07 | 2.76 |
| a R1 sprays were applied on June 2 in Crawfordsville, July 14 in Ames , and July 15 in Kanawah, McNay and Nashua . R3 sprays were applied July 23 in Armstrong, July 27 in Nashua, July 29 in Kanawah, July 30 in Sutherland, July 31 in McNay, August 3 in Ames, and August 4 in Crawfordsville.\*Different (P<0.1) from untreated control |

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| Table 4. Treatments, locations, spray dates, disease ratings, yield for Priaxor (4 oz/A) fungicide spray applied at various times on five Iowa state university research farm fields in 2015. |
|  | Spray dates |  | Disease ratings | Yield |
| Treatment1 | Ames | Armstrong | Kanawah | McNay | Nashua |  | SBS2 | CLB3 | FE4 | Bu/A |
| No spray | -- | -- | -- | -- | -- |  | 65.6 a | 2.1 a | 0.21 b | 74.3 b |
| R1 | July 14 | July 15 | July 15 | July 15 | July 15 |  | 52.9 c | 1.0 b | 0.05 b | 75.5 ab |
| R3 | Aug 3 | Jul 23 | July 29 | July 31 | July 27 |  | 54.7 bc | 1.8 a | 0.13 b | 78.1 a |
| R5 | Aug 12 | ?? | Aug 10 | Aug 11 | Aug 10 |  | 65.2 a | 1.1 b | 1.0 a | 73.9 b |
| 400 h | Aug 3 | Aug 12 | July 29  | Jul 31 | July 27 |  | 58.4 b | 1.9 a | 0.14 b | 74.7 b |
| 700 h | Aug 21 | Aug 20 | Not reached | Not reached | Not reached |  | 57.2 b | 0.95 b | 0.09 b | 76.4 ab |
|  |  |  |  |  |  | P-value | <.0001 | 0.0041 | <.0001 | 0.1769 |
|  |  |  |  |  |  | LSD p<0.1 | 4.1 | 0.5844 | 0.35 | 3.14 |
| 1Timing of Priaxor foliar application: R1; R3: R5; 400 hours of RH>85% from July 1; 700 hours of RH>85% from July 12 Septoria brown spot3 Cercospora blight4 Frogeye  |

Table 5. Treatments and rates of products evaluated for management of foliar disease and yield (bu/A) response in 2016.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Product | Timing | Rate (fl oz/A) | Ames | Armstrong | Crawfordsville | Kanawha | McNay | Nashua | Sutherland |
| Untreated control | --- | --- | 75.7 | 51.7 | 69 | 68.6 | 79.8 | 75.3 | 62.4 |
| Aproach | R3 | 6 | 76.3 | 52 | 67.8 | 66.8 | 82.6 | 77.8 | 62.2 |
| Aproach Prima | R3 | 8 | 76 | 53.6 | 75.4 | 69.6 | 84.5 | 80.9 | 62.9 |
| Custodia | R3 | 8.6 | 79.1 | 55.1 | 75.3 | 66.7 | 82.3 | 75.8 | 65.6 |
| Fortix | R3 | 5 | 79.6 | 53.6 | 72.6 | 69.9 | 79.4 | 78.1 | 61.9 |
| Preemptor | R3 | 5 | 75.2 | 51.7 | 68.9 | 69.5 | 82.2 | 75.4 | 62.0 |
| Priaxor | R3 | 4 | 77.3 | 50.7 | 82.8 | 71.1 | 80.7 | 77.6 | 63.4 |
| Quadris | R3 | 6 | 79.3 | 52.4 | 72.8 | 69.3 | 81.3 | 77.4 | 62.1 |
| Quadris Top | R3 | 8 | 75.2 | 53.6 | 78 | 71.5 | 80.3 | 78.5 | 62.7 |
| Quilt Xcel | R3 | 10.5 | 78.5 | 54.2 | 75.4 | 64.8 | 76.8 | 77.2 | 61.8 |
| Stratego YLD | R3 | 4 | 77.2 | 55.7 | 71.1 | 70.7 | 79.4 | 74.4 | 62.5 |
| Topguard EQ | R3 | 5 | 77.7 | 54.1 | 72.4 | 68.3 | 81.6 | 78.8 | 64.0 |
| Trivapro (Quilt Xcel + Solatenol) | R3 | 10.5 + 4.1 | 76.6 | 53.9 | 72.6 | 67.4 | 85.2 | 75.9 | 60.9 |
| Zolera FX 3.34 SC | R3 | 5 | 83.3 | 50.2 | 69.2 | 68.4 | 81.9 | 76.9 | 63.0 |
| Priaxor | R1 | 4 | 79.5 | --- | --- | 69.7 | --- | --- | --- |
| Priaxor | R5 | 4 | 79.3 | --- | --- | 74.6 | --- | --- | --- |
| P value |   |   | 0.52 | 0.30 | 0.38 | 0.16 | 0.5 | 0.39 | 0.98 |
| CV |  |  | 5.6 | 5.50 | 10.60 | 5.4 | 5.4 | 4.46 | 4.77 |
| LSD (P<0.1) |   |   | 5.20 | 3.50 | 9.20 | 4.40 | 5.20 | 4.1 | 3.6 |
| a All products applied with nonionic surfactant (Induce at 0.3% v/v) unless otherwise noted. |  |  |  |  |  |