**Potential use of cover crops and green manures for localized or widespread management of Fusarium diseases, white mold and iron deficiency chlorosis on soybean**

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More growers are utilizing cover crops in the Midwest, but the impact of cover crop practices on plant diseases is poorly understood. Cover crop plantings can alter soil moisture levels and microbial communities, and consequently may influence the development of soil-borne diseases. Sudden death syndrome (SDS) and iron deficiency chlorosis (IDC) are soil-borne diseases that affect soybean production in Iowa. In the North Central region, fall-sown rye and wheat are two winter-hardy options growers can use for erosion and weed control outside of the growing season. Research in Minnesota has shown that oats, sown as a nurse crop in the spring, can mitigate IDC symptoms in soybean by taking up excess soil moisture and nitrates. In 2019, we conducted field experiments to evaluate the effects of winter rye, winter wheat, and nurse-crop oat cover crops on development of SDS, IDC, and soybean yield. We also conducted greenhouse and lab experiments to determine how cover crops affect disease development and pathogen growth. In addition, we sampled grower fields with tile drainage system to determine if disease pressure is affected by the location of the tile lines.

**Objective 1. Evaluate the effect of cover crops and green manures on SDS, Fusarium root rot, white mold and iron deficiency chlorosis in field conditions**

In 2019, we collected data from 5 fields in Iowa. Winter rye and winter wheat seed drilled late in Fall 2018 emerged early in spring 2019; oats drilled late in Fall 2018 did not emerge. Oats and rye were also established as companion crops when soybeans were planted in Spring 2019. Two soybean varieties were planted at all 5 locations: Asgrow AG2733 (susceptible to iron deficiency chlorosis (IDC) and sudden death syndrome (SDS)) and Asgrow 28X9 (tolerant to both diseases). Cover crops were terminated when soybeans reached the V3 growth stage. We collected data on cover crop biomass, soil moisture, and soybean stand at 4 of the 5 locations. Iron chlorosis and SDS symptoms were assessed throughout the growing season. White mold incidence and severity were evaluated at growth stage R6. Symptoms from the three target diseases were not severe in the 2019 growing season. Both IDC locations had plants with SDS. Soybeans were harvested in late Fall due to excessive moisture in the soil. In general, disease pressure was very low in all trials, probably due to the unusual weather conditions in 2019. Rainfall was slightly below average in June and August, but higher than average in July and September. Detailed results are shown below for the three locations of the study.

**Kanawha, Iowa**

Two field locations were selected at the ISU Northern Iowa Research Farm in Kanawha. More cover crop biomass was produced before termination in the fall-sown treatments than in the spring-sown oats (data not shown). IDC symptoms were observed at low levels in the field with a history of IDC, but there were no treatment differences in IDC disease severity or yield for either variety **(Table 1).** SDS foliar disease symptoms developed late in the growing season at both locations. SDS incidence was very low (0.1 to 6.7% of plants) in the SDS-tolerant AG28X9, and ranged from 5.3 to 16.3% in subplots with the moderately-susceptible AG2733. Within each variety, there were no treatment differences in SDS disease incidence or disease index at either location. At the SDS location, AG28X9 plots without cover crops had higher yields than plots with cover crops, but yields for all four treatments were similar at the IDC location. Yields for AG2733 were not affected by treatment at either location.

**Ames, Iowa**

Two field locations were selected in central Iowa in 2019 (ISU Curtiss Farm & Hinds Farm). Curtiss farm was selected due to previous fields having a history of IDC and SDS, while Hinds farm had a history of SDS. In general, Hinds farm **(Table 2)** had very low disease pressure in both varieties ranging from (0 to 0.4% of plants) in the moderately-susceptible AG2733 and nearly 0% infected plants in the SDS-tolerant AG28x9. Curtiss farm **(Table 2)** had higher disease incidence levels in the moderately-susceptible variety (18.3 to 36.2% of plants) and in the SDS-tolerant variety (1.8 to 3.7% of plants). Regardless, there was no treatment difference on SDS at either location. IDC at the Curtiss farm was low (1.9 to 2.1% of plants) for both varieties. Yield at the Curtiss farm for the no cover crop treatment was higher in the AG2733 variety whereas fall wheat was the highest yielding plot in AG28x9. Regardless, there was no significant difference among treatments at this location. Yields at the Hinds farm had some differences (*P*=0.019) for the AG2733 variety and (*P*=0.55) for the AG28x9 variety. These differences in yield may be due to environmental factors such as sandy soil and the lack of irrigation.

**Nashua, Iowa**

One field experiment was established in northeast Iowa at the Nashua Research Farm to test cover crop impact on white mold. Disease scoring was conducted on a 0-3 scale with a select number of plants: 0 = no infection; 1 = infection on branches; 2 = infection on mainstem with little effect on pod fill; 3 = infection on mainstem resulting in death or poor pod fill. There was very little disease pressure **(Table 3)** with a disease index ranging from (0.6 to 1.4) in AG2733 and (0.5 to 1.3) in AG28x9. There was no significant difference in yield among treatments for either variety.

**Current work:**

Field trials will be repeated in 2020 to evaluate additional growing environments to understand how cover crops may influence soybean diseases. In Fall 2019, we identified 6 field locations for the 2020 growing season and sowed fall cover crops in October 2019. Our 2020 locations will include SDS and IDC fields at Kanawha, IA; one SDS and two IDC fields in the Ames area; and a white mold study at Nashua, IA. Fall cover crops included oats (broadcast into standing crops), winter rye and winter wheat (drilled immediately after 2019 harvest). Spring-sown companion oats and rye will be drilled when soybeans are planted in spring 2020.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 1. Mean yield, iron deficiency chlorosis (IDC) disease score, soybean sudden death (SDS) disease incidence, and SDS disease index observed in Asgrow AG2733 and AG28X9 soybeans planted in two field locations Ames, IA. | | | | | | | | | | | | | | | | | | | | | | | |
|  |  | | Iron Deficiency Chlorosis Location - South Farm | | | | | | | | |  | | Sudden Death Syndrome Location - North Farm | | | | | | | | | |
| Variety | | Cover crop | Yield (bu/ac) | | IDC score4 | | | SDS DI (%)5 | | SDS DX6 | | |  | | Yield (bu/ac) | | | SDS DI (%) | | | SDS DX | | |
| AG27332 | | fall rye | 41.0 (1.8)1 | a | 1.8(.1) | a | 14.6 (8.1) | | a | 6.4 (3.6) | a |  | | 49.8 (2.9) | | a | 14.7 (3.8) | | a | 5.7 (1.8) | | a |
|  | | fall wheat | 37.7 (4.5) | a | 1.8(.1) | a | 7.6 (5.6) | | a | 3.2 (2.5) | a |  | | 44.1 (2.9) | | a | 16.3 (9.2) | | a | 6.9 (4.2) | | a |
|  | | spring oats | 41.6 (1.7) | a | 2.1(.2) | a | 6.8 (4.2) | | a | 2.6 (1.6) | a |  | | 43.5 (2.5) | | a | 9.0 (3.5) | | a | 3.2 (1.2) | | a |
|  | | none | 44.3 (1.9) | a | 1.7(.1) | a | 11.3 (7.9) | | a | 4.7 (3.6) | a |  | | 42.8(2.6) | | a | 5.3 (2.1) | | a | 1.8 (0.7) | | a |
|  | | LSD | 8.03 |  | 0.39 |  | 19.65 | |  | 8.68 |  |  | | 7.62 | |  | 15.88 | |  | 6.98 | |  |
|  | | *P*-value | 0.416 |  | 0.594 |  | 0.835 | |  | 0.803 |  |  | | 0.273 | |  | 0.449 | |  | 0.419 | |  |
|  | |  |  |  |  |  |  | |  |  |  |  | |  | |  |  | |  |  | |  |
| AG28X93 | | fall rye | 49.1 (2.8) | a | 2.5(.2) | a | 0.22 (0.09) | | a | 0.06 (0.03) | a |  | | 47.3 (2.4) | | ab | 0.23 (0.13) | | a | 0.06 (0.03) | | a |
|  | | fall wheat | 49.6 (3.5) | a | 2.8(.2) | a | 6.7 (6.7) | | a | 3.0 (3.0) | a |  | | 44.9 (2.2) | | b | 0.8 (0.5) | | a | 0.25 (0.16) | | a |
|  | | spring oats | 46.6 (3.1) | a | 2.5(.2) | a | 0.19 (0.16) | | a | 0.06 (0.05) | a |  | | 47.2 (1.8) | | ab | 0.23 (0.08) | | a | 0.07 (0.02) | | a |
|  | | none | 48.8 (3.4) | a | 2.3(.2) | a | 0.08 (0.05) | | a | 0.02 (0.01) | a |  | | 51.2 (1.5) | | a | 0.13 (0.10) | | a | 0.03 (0.02) | | a |
|  | | LSD | 9.27 |  | 0.60 |  | 9.82 | |  | 4.37 |  |  | | 5.89 | |  | 0.74 | |  | 0.24 | |  |
|  | | *P*-value | 0.855 |  | 0.368 |  | 0.423 | |  | 0.421 |  |  | | 0.210 | |  | 0.184 | |  | 0.203 | |  |

1Values are treatment means followed by standard deviations (in parentheses).

2Variety AG2733 is moderately resistant to iron chlorosis, and moderately susceptible to SDS and white mold.

3AG28X9 is tolerant to SDS and white mold, and moderately susceptible to iron chlorosis.

4Mean IDC score (1 to 9) rated on July 2 at soybean growth stage V1. A score of 1 = no chlorosis and 9 = plant death.

5SDS DI = incidence of plants with SDS foliar symptoms at the end of the growing season, on 9/17/19.

6SDS DX = foliar symptom score for plot, rated on 9/17/19

Table 2. Mean yield, iron deficiency chlorosis (IDC) disease score, soybean sudden death (SDS) disease incidence, and SDS disease index observed in Asgrow AG2733 and AG28X9 soybeans planted in two field locations Ames, IA.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | Iron Deficiency Chlorosis & Sudden Death Location - Curtiss Farm | | | | | | | | |  | | Sudden Death Syndrome Location - Hinds Farm | | | | | | | | | |
| Variety | | Cover crop | Yield (bu/ac) | | IDC score4 | | | SDS DI (%)5 | | SDS DX6 | | |  | | Yield (bu/ac) | | | SDS DI (%) | | | SDS DX | | |
| AG27332 | | fall rye | 52.1(6.7)1 | b | 2.1(0.1) | a | 34.2(12.2) | | a | 22.5(10.3) | a |  | | 42.9(1.1) | | a | 0.43(0.4) | | a | 0.14(0.13) | | a |
|  | | fall wheat | 60.9(1.4) | ab | 2.0(0.1) | a | 36.2(12.8) | | a | 24.13(10.9) | a |  | | 37.2(2.8) | | b | 0(0) | | a | 0(0) | | a |
|  | | spring oats | 61.3(1.4) | ab | 2.1(.07) | a | 24.3(11.1) | | a | 14.75(9.0) | a |  | | 32.9(2.3) | | b | 0(0) | | a | 0(0) | | a |
|  | | none | 64.3(1.9) | a | 1.9(0.2) | a | 18.3(5.3) | | a | 8.15(2.3) | a |  | | 35.5(3.5) | | b | 0.03(0.03) | | a | 0.01(0.01) | | a |
|  | | LSD | 10.74 |  | 0.35 |  | 31.76 | |  | 26.09 |  |  | | 7.67 | |  | .59 | |  | 0.20 | |  |
|  | | *P*-value | 0.143 |  | 0.455 |  | 0.620 | |  | 0.566 |  |  | | 0.019 | |  | 0.370 | |  | 0.370 | |  |
|  | |  |  |  |  |  |  | |  |  |  |  | |  | |  |  | |  |  | |  |
| AG28X93 | | fall rye | 58.3(7.2) | b | 2.1(0.1) | a | 3.67(0.9) | | a | 0.8(0.2) | a |  | | 43.7(2.7) | | ab | 0(0) | | a | 0(0) | | a |
|  | | fall wheat | 70.5(1.8) | a | 1.9(0.2) | a | 1.83(0.7) | | a | 0.5(0.2) | a |  | | 45.1(2.7) | | a | 0(0) | | a | 0(0) | | a |
|  | | spring oats | 69.5(1.5) | ba | 2.0(0.1) | a | 3.17(0.9) | | a | 0.8(0.2) | a |  | | 35.8(0.8) | | c | 0(0) | | a | 0(0) | | a |
|  | | none | 69.2(1.6) | ba | 1.9(0.2) | a | 2.67(0.8) | | a | 0.8(0.2) | a |  | | 37.1(3.2) | | bc | 0.03(0.03) | | a | 0.01(0.01) | | a |
|  | | LSD | 11.42 |  | .423 |  | 2.56 | |  | 0.57 |  |  | | 7.57 | |  | .05 | |  | 0.01 | |  |
|  | | *P*-value | 0.132 |  | 0.751 |  | 0.507 | |  | 0.510 |  |  | | 0.055 | |  | 0.429 | |  | 0.429 | |  |

1Values are treatment means followed by standard deviations (in parentheses).

2Variety AG2733 is moderately resistant to iron chlorosis, and moderately susceptible to SDS and white mold.

3AG28X9 is tolerant to SDS and white mold, and moderately susceptible to iron chlorosis.

4Mean IDC score (1 to 9) rated on July 2 at soybean growth stage V1. A score of 1 = no chlorosis and 9 = plant death.

5SDS DI = incidence of plants with SDS foliar symptoms at the end of the growing season, on 9/17/19.

6SDS DX = foliar symptom score for plot, rated on 9/17/19

Table 3. Mean yield and white mold disease index observed in Asgrow AG2733 and AG28X9 soybeans

planted at Northeast Research Farm in Nashua, IA.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Nashua |  | | White Mold Location - Nashua Farm | | | |
| Variety | | Cover crop | Yield (bu/ac) | | WM DX4 | |
| AG27332 | | fall rye | 59.3(2.2)1 | a | 1.25(0.5) | a |
|  | | fall wheat | 59.4(1.9) | a | 1.38(0.4) | a |
|  | | spring oats | 60.2(2.3) | a | 0.75(0.4) | a |
|  | | none | 61.7(2.9) | a | 0.63(0.4) | a |
|  | | LSD | 6.79 |  | 1.24 |  |
|  | | *P*-value | 0.510 |  | 0.482 |  |
|  | |  |  |  |  |  |
| AG28X93 | | fall rye | 64.1(2.8) | a | 0.5(0.3) | a |
|  | | fall wheat | 62.4(1.6) | a | 1.13(0.4) | a |
|  | | spring oats | 60.8(1.6) | a | 0.6(0.4) | a |
|  | | none | 63.2(1.3) | a | 0.5(0.3) | a |
|  | | LSD | 5.52 |  | 1.11 |  |
|  | | *P*-value | 0.409 |  | 0.619 |  |

1Values are treatment means followed by standard deviations (in parentheses).

2Variety AG2733 is moderately resistant to iron chlorosis, and moderately susceptible to SDS and white mold.

3AG28X9 is tolerant to SDS and white mold, and moderately susceptible to iron chlorosis.

4White mold DX = symptom score for plot, rated on 9/13/19

**Objective 2. Identify simple, rapid, and cost-effective bioassays to test efficacy of additional cover crop species on disease suppression in controlled environment conditions**

We continued to conduct greenhouse experiments to test the ability of different cover crop amendments (rye, oat, alfalfa, clover and corn) to suppress SDS and other soilborne pathogens. In 2019 we conducted several experiments with SDS. Pasteurized field soil was amended with green manures of the cover crops and infested with spores of *F. virguliforme*. The soil was then incubated for three weeks, after which soybean seeds were planted. Soybean plants were sampled 14 days after planting to assess the treatment effects on root rot severity and growth, and at 28 days after planting to assess root rot and foliar symptoms. In all experimental runs **(Fig 1),** we observed a significant reduction of root rot in soybean grown in soil amended with all the green manure treatments compared to the un-amended control. Suppression with oat and rye amendments tended to be greater than with alfalfa. These results showed that soil amendment with green crop residues reduces the risk of infection by *F. virguliforme*, and that the level of suppression may vary across cover crop species.

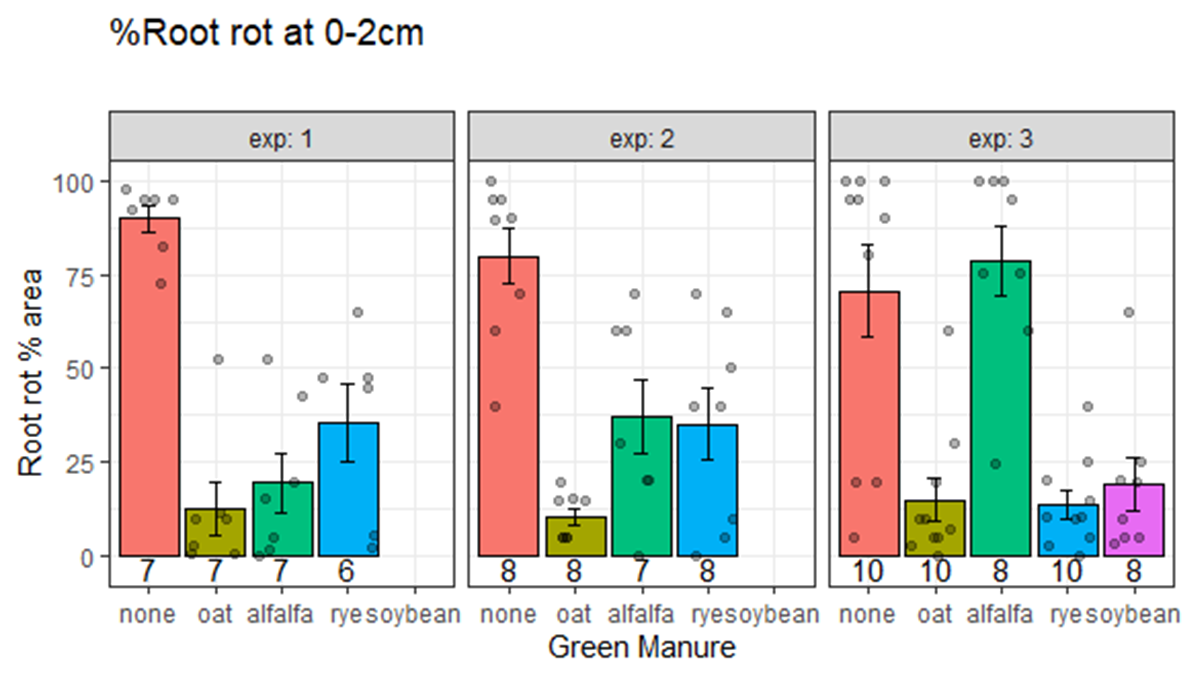


Figure 1. Severity of root rot on soybeans grown in soil with different green manure amendments.

**Current work:** After developing protocols and conducting several experiments with F. virguliforme, we are not conducting similar experiments with *F. acuminatum* and *P. sylvaticum*. These experiments will inform us if the suppression caused by the cover crop green manures also occurs with a broader range of pathogens.

**Objective 3. Identify cover crops with the most potential for inhibiting pathogen growth and sporulation in vitro and survival in soil.**

We conducted lab experiments to determine the effects of cover crop extracts on *in-vitro* growth and sporulation of *F. virguliforme, F. graminearum* and *P. sylvaticum*. Culture media was amended with plant extracts from oats, rye, alfalfa, clover, soybean, and corn. Media with no crop amendment was used as a control. Fv colony growth and sporulation were assessed on the different amended media after 2 weeks. With Fv, we found that spore production was increased by alfalfa, clover, corn and rye but not by oat amendments. With *F. graminearum*, mycelial growth was not affected by oat, clover or alfalfa but was slightly reduced by rye. With *P. sylvaticum*, mycelial growth was increased by rye, clover and alfalfa but was not affected by rye. These results suggest that green cover crop residues provide nutrients that stimulate growth and sporulation of some pathogens but in general do not have a strong inhibitory effect.

We have also started petri dish assays to examine the impact of cover crop extracts on *P. sylvaticum*, *F. acuminatum*, and *F. virguliforme*. Oat and rye extracts were obtained by both a tea and slurry method. Cover crop extracts in the tea method were finely chopped and placed within a tea bag, which was set in 30 mL of water and refrigerated overnight. Slurry extracts were obtained by grinding cover crops in a blender or mortar and pestle with 30 mL of water and then centrifuged. Cover crops extracts were then placed one one side of a petri dish in either a well or on soaked filter paper discs. One plug of each pathogen was placed at the opposite end of the petri dish. Each assay was run twice and water was used as a control. The growth pattern of the pathogens was observed daily to determine if a zone of inhibition could be detected. This would have indicated that the extracts were negatively affecting growth. Our results showed that oat or rye extracts have no effect on *P. sylvaticum*. However, the growth of *F. acuminatum* appears slightly altered by rye extracts. Further work is needed to confirm these results.

In a second in vitro assay, we tested if rye and oat extracts affected spore germination. Spores of *F. virguliforme* and *F. acuminatum* were added to cover crop extracts. A droplet of spore suspension was placed onto glass cover slips and placed in incubated for 6 hrs. Droplets were then allowed to dry and then stained with .15% aniline blue in lacto phenol. Slides were then viewed under a microscope to quantify germination rate. We found that both oat and rye accelerated *F. virguliforme* spore germination compared to water. Results for *F. acuminatum* are being collected.

**Current work**: We will continue to conduct in-vitro assays to determine how cover crops affect pathogen growth in Fusarium and Pythium species. In addition, we will conduct experiments with the white mold pathogen, S*clerotinia sclerotiorum*. We will soak sclerotia formed by this pathogen in cover crop tea and slurry, and then test if this affects germination of the sclerotia. All experiments will be repeated and results summarized in future reports.

**Objective 4. Establish soilborne pathogen baseline data for testing the use of cover crops for precision**

**management of soil health.**

Recently, some growers have suggested that soybeans grown over drainage tiles have higher levels of disease pressure than soybeans growing between tile lines*.* In 2018, we conducted a preliminary study and we obtained more *F. virguliforme* isolates and higher SCN counts from soil samples taken over tile lines than between lines. In2019, we expanded the study to more fields and did a more extensive sampling. Four tiled fields in northwest Iowa were evaluated when visual signs of SDS were noticeable. Aerial images, plant samples, and soil samples were collected from areas over drainage tiles and areas between the drainage tiles. Soybean roots were plated to assess frequency of infection and soil samples were submitted to Pattern Ag for nutrient and microbial profiling.

Root isolations showed *F. virguliforme* was present in 76% of the root pieces of plants sampled over drainage tiles and in 60% of root pieces from plants sampled from areas between the drainage tiles. We are awaiting results from Pattern Ag to compare microbial communities and soil nutrients over and between tile lines. We are also obtaining SCN counts from the Tylka lab.

**Current work:** In 2020, we will analyze the 2019 data from Pattern AG, image analysis, and SCN counts, and we will repeat the study on more field.