**FY 2021 Year-End Technical Report ND Soybean Council**

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**Title of Project:** Utility of a Barley Crop for Iron Deficiency Chlorosis and Waterhemp Management

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**Introduction**

Iron Deficiency Chlorosis (IDC) is a major problem to soybean production in the upper Midwest due to the alkaline soils in these areas (Naeve 2006). IDC can be characterized by the stunting of the soybean plant, delayed canopy closure, along with yellowing and interveinal chlorosis within the leaves, especially of early trifoliolate leaves (Bai et al. 2018). Hansen et al. (2004) indicated that IDC costs soybean growers 120 million U.S. dollars in North Dakota, South Dakota, and areas in western Minnesota annually. The blending of a companion crop to be terminated in-season has the potential to increase overall health of the soybean within the field early in the season (Naeve 2006). This could also be beneficial through an economic standpoint, as purchasing a companion crop would cost less when compared to purchasing herbicide resistant soybean and increasing the overall rate of soybean within the field (Naeve 2006). Some crops, such as oat, can also be conveniently terminated by using one of many different herbicide systems, such as glyphosate, if combined with glyphosate-resistant soybeans (Naeve 2006) that are already regularly planted throughout the Midwest. If the companion crop is only growing during the vegetative stages of soybean to mitigate IDC symptoms, this correlates well with the timing at which the companion crop would need to be terminated to avoid yield loss due to competition. Companion crops compete with both the cash crop and weeds for light and nutrients, reducing the biomass and density of weeds, and reducing yield of the cash crop (Verret et al. 2017; Naeve 2006).

Research supports that a companion crop planted alongside soybean will reduce symptoms of IDC. The mechanism behind IDC symptom mitigation is largely unknown, although the presence of greater total plant biomass has been shown to mitigate the symptoms of IDC (Naeve 2006). It has been theorized that companion crops are able to absorb excess nitrates. Kaiser et al. (2014) observed that soybean planted with oat as a companion crop had reduced trifoliate nitrate N and Fe within the soybean plants. The increased plant biomass can also come from increasing the planting rate of the soybean within a field, which reduced IDC symptoms as well as increased final soybean yield (Naeve 2006). Previous research about utilizing an oat companion crop in soybean was conducted in fields without glyphosate resistant weeds. Glyphosate-resistant waterhemp (*Amaranthus tuberculatus*) has become a prevalent weed in many fields where IDC is also problematic. Waterhemp is becoming more difficult to manage in soybean fields in the Northern Great Plains, and utilizing a companion crop to manage waterhemp may prove beneficial, particularly in fields susceptible to IDC.

**Objectives of the Research:**

1) Evaluate barley/oat suppression of waterhemp in soybean.

2) Evaluate the time from planting to canopy closure of IDC-sensitive soybean with and without a barley/oat cover crop, and the effect of earlier canopy closure on late-season waterhemp management.

3) Evaluate the optimal termination timing of a barley/oat cover crop to alleviate IDC symptoms and reduce yield loss due to direct competition of the cover crop with soybean.

**Materials and Methods:**

Trials were initiated at NDSU’s Northwest 22 research site near Fargo, ND on May 19, 2020, and at a research site near Prosper, ND on May 24, 2020. The soil near Fargo is a Fargo Series, Silty Clay with 5% OM and a pH of 7.4; while the soil near Prosper is a Kindred-Bearden Silty Clay Loam with 4.3% OM and a pH of 7. The experiment was a 2x5x2 factorial treatment structure arranged in a RCBD split-block with one four replications. Treatment factors were A) Presence of oat companion crop, B) termination timing of the companion crop and C) number of POST herbicide applications. Factor A had two levels, oat and no oat. Factor B had 5 levels: 6, 12, 18, and 24 inch oat height used to determine termination timing, as well as a no oat termination. Factor C had two levels, one or two POST treatments of herbicide. A weed-free, oat-free treatment was included for comparison. The main pigweed species at the Fargo location was waterhemp (*Amaranthus tuberculatus*), while the main pigweed species seen at the Prosper location was Powell amaranth (*Amaranthus powelli*).

Oats (ND Rockford) were drilled in 7.5-inch rows at a seeding rate of 60 pounds per acre and a 1-inch depth. Soybeans (AG06X8) were planted in 30-inch rows at a seeding rate of 156,000 seed per acre and a 1.5-inch depth. Glyphosate (1.125 lb ae A-1) and dicamba (0.5 lb ae A-1) were applied when oats were 6, 12, 18, and 24 inches tall to terminate the companion crop and provide weed control. Any plots with a secondary POST treatment were applied with the same mixture of herbicide 14 days after the initial termination. Treatments were applied with a CO2-pressurized backpack sprayer calibrated to deliver 15 GPA at a speed of 3 MPH with TTI 11002 (Turbo TeeJet Induction, TeeJet Technologies, Glendale Heights, IL) in 20 inch spacing with 28 PSI of pressure.

Weed densities and biomass were recorded at each termination timing. All plants were collected from a 1-m2 quadrat, and were clipped at the soil surface and dried at 43 degrees C for 14 days. Visual IDC scores were assigned to each plot every other week and chlorophyll content was measured with a Soil Plant Analysis Development (SPAD) Logger at that time. The visual IDC ratings were recorded using the visual system developed by Helms and Kandel (2020), whereby plots were rated on a scale of 1-5, with 1 representing no symptoms and with a 5 being a dead plant (Helms and Kandel, 2020). The trial at Prosper was harvested on October 6, 2020 and the trial at Fargo was harvested on October 22, 2020. All data were analyzed using a three-factorial analyzation to account for the three different factors within the experiment with PROC GLIMMIX (SAS 9.4) using means separation with Tukey’s HSD test (α < 0.05).

**Results:**

It is worth noting that the plots were planted as soon as soils were dry enough to do so this spring. The seedbed quickly dried out and the first significant rainfall did not occur until June 7. This led to early season moisture competition between oats, soybean, and weeds. Fargo was particularly dry with no rainfall until 19 days after planting, and with a flush of waterhemp occurring soon after planting.

There were minimal IDC symptoms this year on the Xtend variety planted in the trials. There were no differences in IDC symptoms or chlorophyll content between treatments at Prosper. At the Fargo location, there was a slight increase in chlorophyll content in plots with the oat crop compared to plots without oats (data pooled across all termination timings).

The presence of an oat companion crop had no effect on waterhemp (Fargo) or Powell amaranth (Prosper) densities at any termination timing compared to plots without oats. The presence of the oat crop also had no effect on pigweed biomass at either location at the 6 or 12 inch termination timings. Pigweed biomass was lower in plots with oats compared to plots without oats at both locations at the 18 and 24 inch termination timings. Results at both locations suggest that oat suppression of pigweeds did not begin until after oats were 12-inches tall when oats and pigweeds germinate at the same time.

A

AB

B

AB

A

A

Figure 1. Biomass of waterhemp at Fargo location in grams per square meter at different termination timings triggered by height of oats. Green bar represents biomass in plots withou t oats, while gold bars represent biomass in plots with oats present.

AB

AB

AB

AB

C

A

A

BC

Figure 2. Biomass of Powell amaranth at Prosper location in grams per square meter at different termination timings triggered by height of oats. Green bar represents biomass in plots without oats, while gold bars represent biomass in plots with oats present.

There were no differences in Powell amaranth control across any termination timings at Prosper. This is due to glyphosate controlling the glyphosate-susceptible Powell amaranth plants. Waterhemp control was greatest at the 6-inch termination timing, but was not different between plots with or without oats. There was less control at later termination timings, and control would not be deemed commercially acceptable at any application after the 6-inch termination timings on the glyphosate-resistant population tested.

A

AB

AB

B

Figure 3. Percent control of waterhemp 14 days after treatment. Y-axis is percent visible control on a scale of 0 to 100. X-axis represents different application timings based on oat height in plots with oats. Data are pooled across plots with and without oats.

Yield was more affected by treatments at the Fargo location than at Prosper. At Fargo, the plots with oats always yielded less than plots without oats across all termination timings. The two treatments with the highest yield were herbicides applied to plots without oats at the 6 and 12-inch termination timings. These still resulted in less yield than plots that were maintained weed-free throughout the year. At Prosper, there were no differences between plots with oats or without oats at any termination timing. The treatments with highest yield were the weed-free check and plots where herbicides were applied at the 6 and 12 inch termination timings. Delaying the first herbicide application until 18 or 24 inch termination timings resulted in lower yield.

A

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C

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C

B

B

A

C

C

Figure 4. Soybean yield at Fargo location. X-axis represents different application timings based on oat height in plots with oats. Green bar represents biomass in plots without oats, while gold bars represent biomass in plots with oats present. The weed-free, oat-free check had a yield of 2009 kg ha-1.

AB

AB

B

B

A

A

A

A

C

C

Figure 5. Soybean yield at Prosper location. X-axis represents different application timings based on oat height in plots with oats. Green bar represents biomass in plots without oats, while gold bars represent biomass in plots with oats present. The weed-free, oat-free check had a yield of 3670 kg ha-1.

Altogether, the oats did not provide suppression of pigweeds until the oats were 18-inches tall. Delaying first herbicide application until oats were 18-inches tall also resulted in lower soybean yields. Control of glyphosate-resistant waterhemp was reduced at later termination timings, and a follow-up treatment was necessary in all treatments in order to obtain complete control. This indicates that in the absence of any preemergence herbicide, a postemergence application would need to be applied prior to 6 inch tall oat in order to achieve complete waterhemp control with one postemergence application. IDC symptoms were minimal and transient on the variety used in these trials, and the addition of oats did not add significant value to weed control until oat was too competitive with soybean in 2020. This research is being repeated in 2021.

**Literature Cited**

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