**MISSISSIPPI SOYBEAN PROMOTION BOARD**

# Managing Iron Deficiency Chlorosis (IDC) Through a Cropping System Approach, Project 12-2022 Final Report

PI: Mary Love Tagert, mltagert@abe.msstate.edu, Ph. 662-325-4617
Co-PIs: Michael Cox, mcox@pss.msstate.edu, Ph. 662-325-2311
Mark Harrison, mph31@msstate.edu, Ph. 662-566-2201
Nuwan Wijewardane, nuwanw@abe.msstate.edu, Ph. 662-325-8536

## Rationale and Justification:

There have been numerous studies in other states on different management strategies to address IDC and what factors are causing the symptoms and intensity. One study indicated that using an oat companion crop increased soybean yields in affected areas of a field. It has also been noted that soybeans planted in tractor wheel tracks in Mississippi and Minnesota IDC-prone fields have greener plants due to soil compaction. Soil compaction is considered a poor management system for farmers and reduces yields, but this tractor wheel compaction is thought to reduce soil nitrate levels by creating slightly anaerobic soil conditions that can result in nitrogen loss by denitrification. Usually in fields with low soil nitrate levels, plants are not as green. In the case of iron chlorosis, higher soil nitrate levels make iron chlorosis symptoms worse. These same studies in the north central US have also noted that wet soil conditions aggravate IDC by causing a buildup of carbon dioxide in the soil, which results in a proportional increase of bicarbonate. The bicarbonate neutralizes the acidity around the soybean root so that the insoluble iron cannot be converted to a soluble form that plants can uptake. However, in Mississippi, the opposite seems to occur. Some researchers have indicated that higher seeding rates (200,000 – 250,000 plants/acre) with wide row spacing in chlorosis-prone areas have increased yields by utilizing more nitrate and reducing IDC issues. Variety selection has been the most common method for reducing losses from IDC, but no single researcher has implemented a multiple cropping system approach. This project has put all cropping systems mentioned together in one field with the goal of finding relief from IDC and reducing yield loss. While three years of the plot-scale study have been conducted, the soil moisture data was lost during Year 1 due to issues with datalogger malfunction and maintenance. In addition, due to personnel changes at the station, corn was not planted in 2019 for the corn stubble plots needed during the 2020 growing season. For these reasons, we propose to extend the plot-scale study at least one more year for the 2022 growing season. New objectives are also added in this proposal to apply preliminary results from the plot scale study to a production field. Previous research shows that management factors that benefit areas affected by IDC conversely reduce yields in unaffected areas of the field, indicating that *site specific management* is needed for areas of the field prone to IDC.

## Objective 1: Determine if seven selected cropping systems will improve soybean yields for the three selected varieties that have low tolerance to IDC and increase yield capabilities for the three selected varieties with strong tolerance to IDC.

Small grain (oat) cover crop plots were terminated on April 5, 2022 with 32 oz. of RoundUp PowerMax. Seven cropping systems (Table 1) served as the main plots with six soybean varieties (Table 2) as two-row subplots. All treatments were planted on May 12, 2022 on 38-in raised beds and were replicated four times. Sub-plots 3-6 of cropping system 1 (corn stubble @ 160K) were re-planted across all 4 reps on May 24, 2022. With six sub-plots per cropping system, there are a total of 168 sub-plots (42 treatments per replication). At planting on May 12$^{th}$, composite soil samples were taken for each cropping system across all reps for a total of 28 samples. Samples were sent to the MSU soils lab for a pH and nutrient analysis. Bulk density samples were also taken for each cropping system on May 31, 2022, and visual ratings began this day for each of the sub-plots. Chlorophyll content was also recorded for each sub-plot across all replications using a SPAD 502DL Plus chlorophyll meter beginning on June 7th, where two readings are taken from each row of the sub-plot (4 total readings) and averaged and recorded as the representative value. Beginning on June 16, 2022, plant height was recorded for each Asgrow sub-plot (56 total sub-plots), and leaf area index (LAI) was measured using a Li-Cor 2200C Plant Canopy Analyzer. Each of these parameters was recorded weekly throughout the growing season (5/31, 6/7, 6/16, 6/23, 6/29, 7/7, 7/14, 7/22, 7/28, 8/4, 8/11, 8/31, 9/9) for a total 13 dates. Plots were desiccated on October 4 and harvested on October 11.

Visual IDC ratings and grain yield were analyzed in SAS 9.4 using a two-way analysis of variance (ANOVA) test to determine if there were any significant differences between the cropping systems and tolerant and susceptible varieties, and a Fisher's protected Least Significant Difference (LSD) test was used to identify which cropping systems and varieties were statistically different. When averaged across all years of the project, few significant differences in IDC visual ratings were found among the cropping systems. When looking at the average IDC visual rating for cropping system including all varieties and replications across all four years of the project, planting after soybeans at 120,000 seeds/acre with a roller/packer produced the highest (i.e., most symptomology) average visual rating. While the average visual rating for this cropping system was not significantly higher than that of the cropping system planting after soybean with a roller/packer at 160,000 seeds/acre, it was significantly higher than all other cropping systems. When separated by tolerant and susceptible varieties, susceptible varieties had significantly higher visual IDC ratings for all systems except for planting after soybean with an oat cover and roller at 160,000 seeds/acre. When analyzing the average soybean grain yield of each cropping system including all varieties and replications across all four years of the project, the cropping systems with a corn rotation produced significantly higher grain yields than the other five cropping systems. Furthermore, susceptible variety performance within the corn rotation systems were statistically similar or higher than tolerant variety performance within the other five systems. This means when rotating with corn, producers have the option to plant a more susceptible variety and still experience an increase in grain yield.

**Objective 2: Evaluate the relationship of soil moisture to iron chlorosis symptoms across cropping systems using soil moisture sensor data.**

Beginning June 15, 2022, two sets of Watermark granular matrix sensors were installed in each cropping system across all replications, one set in the higher tolerant Asgrow sub-plot (AG52X9) and the other set in the susceptible Asgrow sub-plot (AG53XF2). Each set consisted of one sensor each at 12- and 24-inch depths. These two varieties were originally selected in Year 2 of the project (2020) because of the amount of data available on their production in soil types similar to that of the study area. Each sensor was connected to a Watermark 900M datalogger that records an hourly soil tension reading (in centibars). Starting June 23, 2022, each datalogger was checked weekly for proper functioning, and data was downloaded via data shuttle. Sensors and dataloggers were removed on Sept. 28.

For data analysis, the assumption was made that the SWT collected in the Asgrow subplots would be representative of the cropping system and therefore included all varieties. A two-way ANOVA test and Fisher's protected LSD test were used to determine significant differences in SWT, IDC visual ratings, and grain yield among the cropping systems. Overall, SWT had a moderate to strong positive correlation to IDC visual ratings and a moderate to strong positive correlation to grain yield. Where significantly lower IDC visual ratings and significantly higher grain yield were found, drier conditions were experienced throughout the growing season and vice versa. Overall, these findings are conclusive with previous research in the Midwest but contradict the anecdotal observations of northeast Mississippi producers.

**Objective 3: Compare vegetation indices derived from UAV imagery to visual ratings and yield from the plot-scale study.**

Starting on June 3, 2022, the plots were flown for multispectral imagery via UAV which continued each week until senescence (Aug. 25, 2022). The imagery was processed by the Mississippi State University (MSU) Geosystems Research Institute. Image derived NDVI (ID-NDVI) was obtained by creating polygons for each Asgrow subplot and using the zonal statistics function to calculate a mean NDVI value. Calculated NDVI (C-NDVI) values were obtained using a rearranged exponential relationship from Fan et al. (2009) and the in-situ LAI measurements. The correlation of C-NDVI and ID-NDVI was calculated to determine the relationship between the two. $R^2$ values of 0.9682 and 0.8993 were found for 2021 and 2022, respectively. This indicates that both parameters are a reliable source to use in management zone delineation. To determine which parameter could be considered more reliable, the correlation between each NDVI value and IDC visual ratings, chlorophyll content, and grain yield were calculated (Table 3). Overall, ID-NDVI had a stronger correlation than C-NDVI in all instances other than grain yield in 2022. These results conclude that ID-NDVI is a reliable parameter for IDC management zone delineation and is much more efficient to collect and manage than the C-NDVI measurements.

**Objective 4: Use results from Objective 3 along with electrical conductivity and other relevant field data to develop management zones for IDC management in a production field.**

The production field we are using is located in Okolona, MS (Monroe County), and we focused on sections of two fields that were identified by the producer as IDC-prone. Approximately half of the approximate 40 acre production study area was rotated with corn (planted in 2021), with the other half being planted behind soybeans. Starting on June 3, 2022, the study area was flown for imagery via UAV each week by the MSU Geosystems Research Institute until the week of August 25, 2022. Pix4D and Agisoft software packages were used to process the imagery and calculate NDVI for the study area. Apparent soil electrical conductivity ($EC_a$) was mapped over sections of the production field on October 28 using a Dualem-1 sensor. Soil $EC_a$ was collected at 0-6- and 6-18-inch depths in milliSemens/meter (mS/m). The NDVI imagery was loaded into ArcMap to identify areas of lower NDVI values. The Geostatistical Analyst > Kriging function was used to create an interpolated map of both soil $EC_a$ depths. A preliminary management zone of the study area was created using the combination of high soil $EC_a$ and lower NDVI values. These areas were also part of ground-truth observations made throughout the growing season.

**Objective 5: Share project results with producers and stakeholder groups.**

An oral presentation focusing on the 2nd objective of the project, titled “Understanding the Effects of Soil Moisture on Iron Deficiency Chlorosis (IDC) in Soybean”, was presented by graduate student Katelin Waldrep at the Mississippi Water Resources Conference on April 13, 2022. Results from Objective 3 were presented at the 2022 ASABE Annual International Meeting in Houston, TX on July 20, 2022, and a conference paper “UAV Multispectral Imagery for Site -Specific Management of Iron Deficiency Chlorosis (IDC) in Soybean” on this presentation was also published. The project was featured as a research highlight by the Soybean Research and Information Network in an article titled “What Crop Management Practices Alleviate Iron Deficiency Chlorosis?” and was published in July 2022. Project results were shared by Dr. Mary Love Tagert and graduate student Katelin Waldrep to area stakeholders at the North Mississippi Research and Extension Center field day on August 17, 2022. The presentation included a handout highlighting the project and results from Objective 1 for the previous three years (2019, 2020, 2021). Katelin Waldrep made an oral presentation at the ASA Southern Branch Meeting in Oklahoma City, OK on February 5, 2023. A poster was presented at the Producer Advisory Council Meeting at the North Mississippi Research and Extension Center in Verona, MS on February 16, 2023. Graduate student Katelin Waldrep successfully defended her thesis titled, “Managing Iron Deficiency Chlorosis (IDC) in Soybean Through a Cropping System Approach” on March 23, 2023.

## Graphics/Figures

Table 1. Cropping system descriptions.

| Cropping Systems for Mitigating IDC in Soybeans | |
|---|---|
| **CS 1** | corn stubble @ 160,000 seeding rate |
| **CS 2** | corn stubble plus small grain cover @ 160,000 seeding rate |
| **CS 3** | soybean stubble plus small grain cover @ 160,000 seeding rate |
| **CS 4** | soybean stubble, small grain cover, plus a roller/packer @ 160,000 seeding rate |
| **CS 5** | soybean stubble and a roller/packer @ 160,000 seeding rate |
| **CS 6** | soybean stubble and a roller/packer @ 120,000 seeding rate |
| **CS 7** | soybean stubble @ 160,000 seeding rate |

Table 2. Tolerant and susceptible varieties used in the study.

| Tolerant Varieties | Susceptible Varieties |
|---|---|
| Asgrow 52X9 | Asgrow 53XF2* |
| Pioneer 53A67X | Pioneer 47A64X* |
| Delta Grow 48X05 | Delta Grow 48X45* |

*Varieties introduced to the study in the 2022 growing season.

Table 3. $R^2$ values for C-NDVI and ID-NDVI with IDC visual ratings, chlorophyll content and grain yield for each growing season.

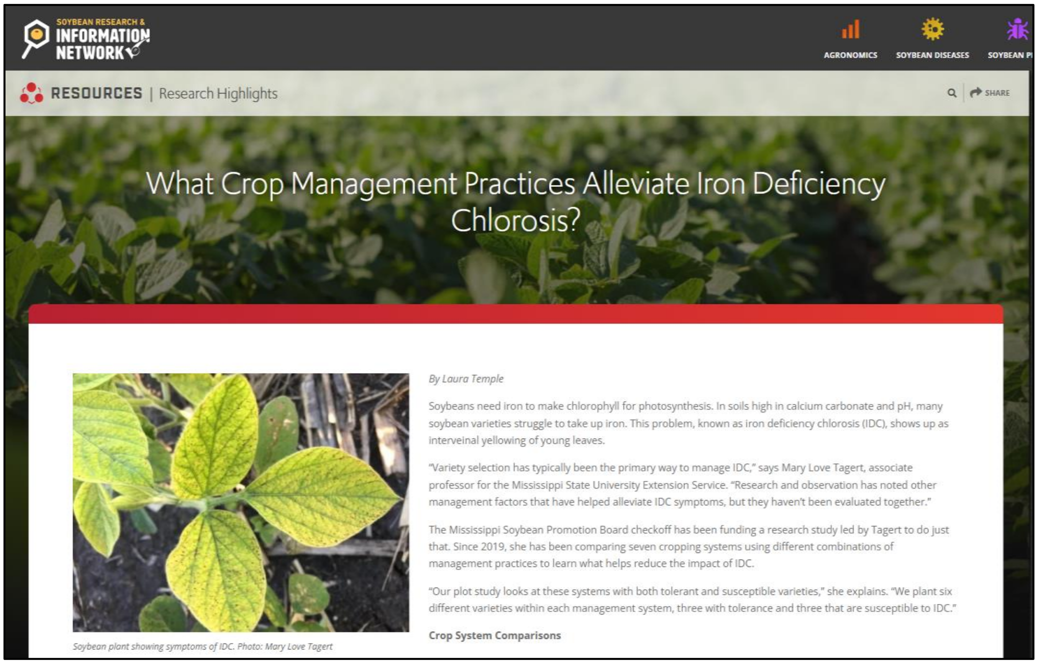
| Growing Season | IDC Visual Rating | | Chlorophyll Content | | Grain Yield | |
|---|---|---|---|---|---|---|
| | *C-NDVI* | *ID-NDVI* | *C-NDVI* | *ID-NDVI* | *C-NDVI* | *ID-NDVI* |
| **2021** | 0.9581 | 0.9819 | 0.8069 | 0.8632 | 0.9066 | 0.9338 |
| **2022** | 0.8770 | 0.9109 | 0.1953 | 0.2050 | 0.6483 | 0.5992 |

Figure 1. Planting treatments on May 12, 2022.

Figure 2. Weekly data collection of chlorophyll content using SPAD 502DL on June 16, 2022. Note the symptomology displayed in the background.

Figure 3. Asgrow 52X9 in cropping systems ‘planting after soybean + roller/packer at 120,000 seeds/acre’ (left) and ‘planting after corn + oat cover crop at 160,000 seeds/acre’ on June 29, 2022 – 48 days after planting.


Figure 4. Katelin Waldrep giving an oral presentation at the 2022 ASABE Annual International Conference in Houston, TX on July 20, 2022.



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What Crop Management Practices Alleviate Iron Deficiency Chlorosis?

Soybean plant showing symptoms of IDC. Photo: Mary Love Tagert

By Laura Temple

Soybeans need iron to make chlorophyll for photosynthesis. In soils high in calcium carbonate and pH, many soybean varieties struggle to take up iron. This problem, known as iron deficiency chlorosis (IDC), shows up as interveinal yellowing of young leaves.

"Variety selection has typically been the primary way to manage IDC," says Mary Love Tagert, associate professor for the Mississippi State University Extension Service. "Research and observation has noted other management factors that have helped alleviate IDC symptoms, but they haven't been evaluated together."

The Mississippi Soybean Promotion Board checkoff has been funding a research study led by Tagert to do just that. Since 2019, she has been comparing seven cropping systems using different combinations of management practices to learn what helps reduce the impact of IDC.

"Our plot study looks at these systems with both tolerant and susceptible varieties," she explains. "We plant six different varieties within each management system, three with tolerance and three that are susceptible to IDC."

Crop System Comparisons

Figure 5. Research highlight featured on the Soybean Research and Information Network website.