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Management Strategies for Iron Deficiency Chlorosis in Soybeans from a System's Approach: Variety Selection, Iron Chelates and Seeding Rates

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Introduction

- Iron Deficiency Chlorosis (IDC) is one of the most yield damaging maladies of soybean in western Minnesota.
- Iron Deficiency Chlorosis is a soil borne abiotic stress caused by a lack of soluble iron (Fe II) to the plants.
- IDC symptoms include interveinal chlorosis and stunting of the plants.
- Crop rotations, variety selection, seeding rates, rows spacing, iron chelates, and even cover crops or companion crops are utilized today. However, each of these strategies comes at some cost.

Objectives

1. Examine yield response to the interactive effects between varieties, populations, and iron chelate rates across a range of IDC levels.

2. Develop an economic model informing producers about ROI for each management strategy individually or collectively in a way to maximize economic returns across fields and farms.

3. Develop a model to predict grain yield based on timing and intensity of IDC using drone imagery.

Materials and Methods

1. Field Sites:
- Three locations: Danvers, Foxhome and Graceville-MN
- To vary the intensity of IDC, plots were placed in two areas within each producer field: a "hot-spot" and a "neutral-spot".

2. Experimental Design:
- Randomized complete blocks with split plot treatment design
- Four replications
- Plot size: 9 x 3 m in 4 x 76 cm rows

3. Treatments: 24 Treatments
- Iron Chelates (Soygreen): 0, 2.24 and 4.48 kg/ha
- Varieties: Moderately Tolerant (AG12XF1) vs Tolerant (AG13XF0)
- Population: 125,000 and 175,000 plants/a
- Nitrogen application to increase IDC intensity: Nitrogen (0.45 kg urea/plot) vs No Nitrogen

4. Data collection: Weekly after emergence
- Visual Scores (Greenness Scores)
- Ground-based NDVI (crop canopy sensor)
- Drone Imagery (DJI Inspire 2 + Micasense RedEdge-MX
- After harvest, samples weight converted to yield (adjusted to 130g/kg)

6. Statistical Analysis: Data was analyzed in R 4.0.3
- The lmer function in the *lme4* package was used to create a linear mixed model
- Analysis of Variance (ANOVA) was used to test the fixed effects of the factorial arrangements of treatments and environments and their interactions
- Mean separation assessment using Tukey's HSD ($P < 0.05$)

Materials and Methods (Continued)

Figure 1. Experimental plots being planted at Graceville on May 10th 2021, the monitor of the tractor showing how different rates/volumes of iron chelates were applied, and urea application as a method to increase the intensity of IDC.

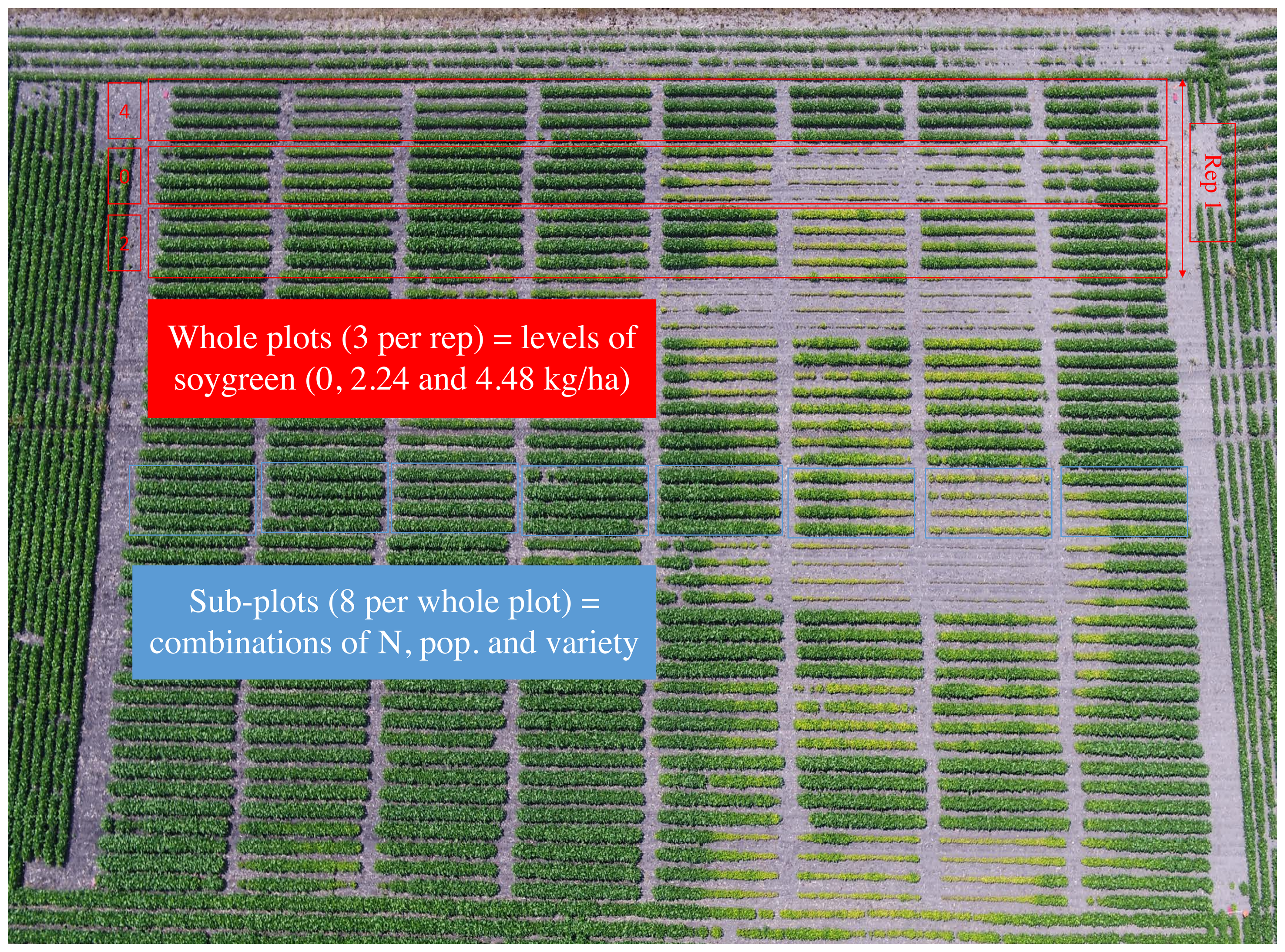

Figure 2. Soybean Iron Deficiency Chlorosis testing site near Danvers, MN.. The red rectangles represent the main plots (levels of Soygreen) and the blue rectangles the sub-plots (all combinations of Variety, Seeding Rate , and Nitrogen application),

Figure 3 A, B, C and D. Soybean plots at reproductive stage with different IDC severities. Following the 1-5 severity rating protocol for visual chlorosis scoring, the following scores would be given to each plot: A = 1, B = 3, C = 4, and D = 5. **Figure 3 E and F, respectively**. Ground-based NDVI and drone imagery data being collected.

Acknowledgments

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Minnesota Soybean Research & Promotion Council
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Preliminarily Results

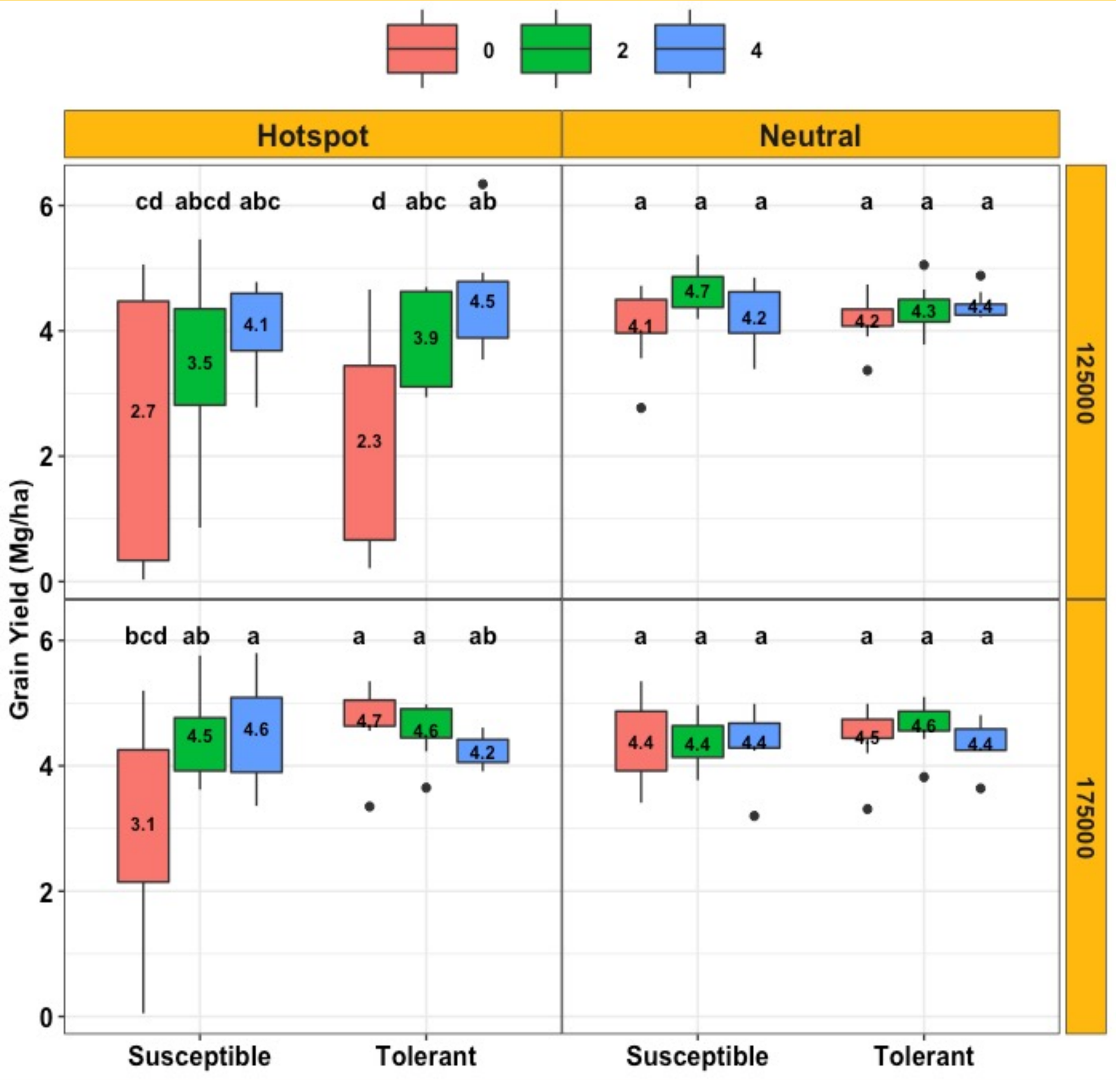

Figure 4. Soybean yield (Mg/ha) by Variety, Seeding Rate and Iron Chelates given Type for Danvers, MN. Letter not connected by the same color were significant at *P*<0.05 using Tukey's HSD.

At Danvers, a four-way interaction was found between Type, Soygreen, Variety and Population. Therefore, a separate analysis was performed within each Type to test for treatment effects.

NEUTRAL:
- ➢ There were no differences in grain yield between treatments.

HOTSPOT:
- ➢ Without Soygreen applied, higher seeding rates increased yield of the tolerant variety.
- ➢ In the susceptible variety, an increased rate of Soygreen from 0 to 4.48 kg/ha significantly increased yield, but only in higher seeding rate treatments.
- ➢ At increased seeding rates without Soygreen, the tolerant variety produced 52% more than the susceptible variety.

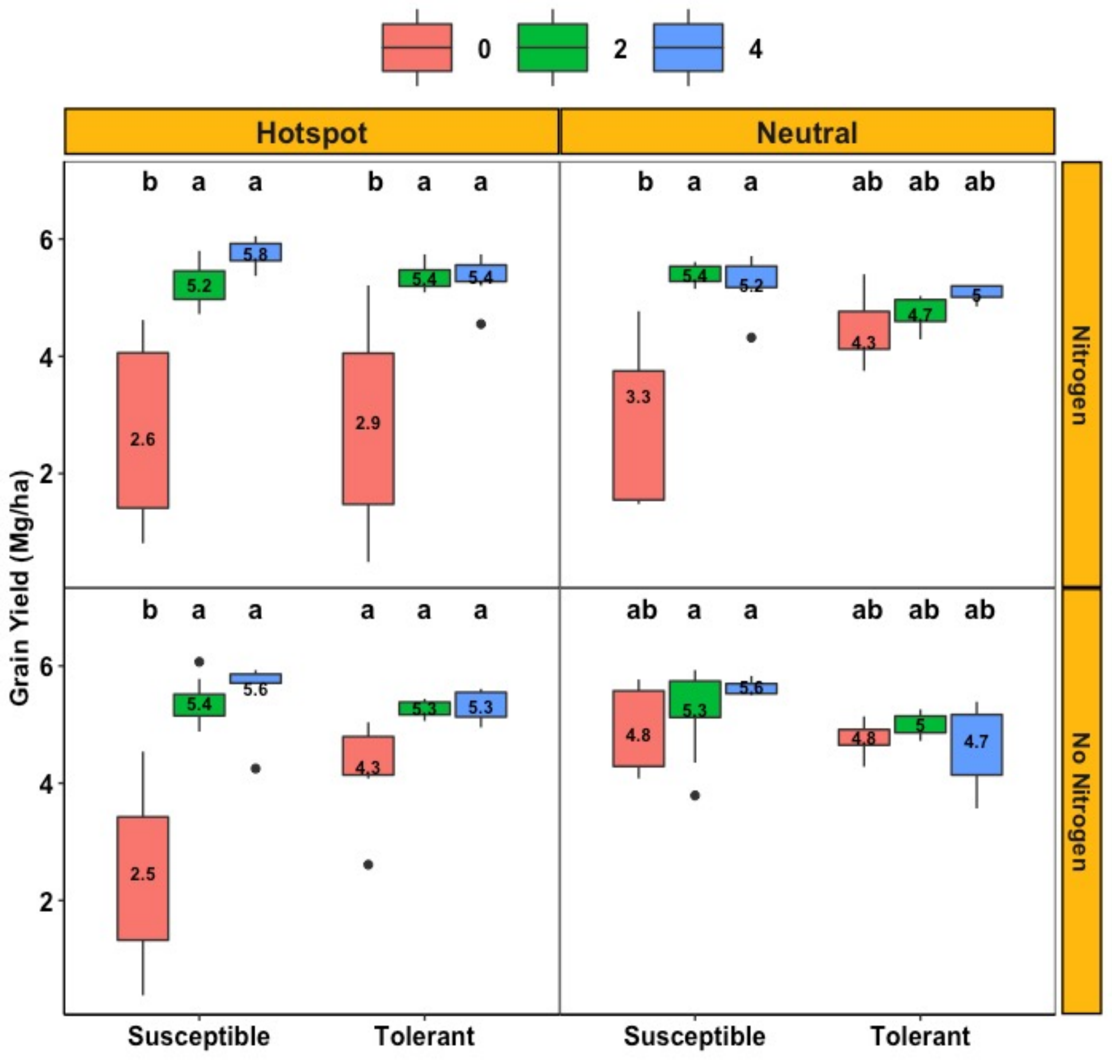

Figure 5. Soybean yield (Mg/ha) by Variety, Iron Chelates and Nitrogen application given Type for Graceville, MN. Letter not connected by the same color were significant at *P*<0.05 using Tukey's HSD.

At Graceville, a four-way interaction was found among Type, Soygreen, Variety and N. Therefore, a separate analysis was performed within each Type to test for treatment effects.

NEUTRAL:
- ➢ Application of Soygreen increased soybean yield by 54 to 60% in the susceptible variety where IDC was amplified by N addition.

HOTSPOT:
- ➢ Regardless of variety, Soygreen application increased yield when N was applied.
- ➢ Where N was not applied and no Soygreen was added, a tolerant variety yielded 72% more than a susceptible variety.

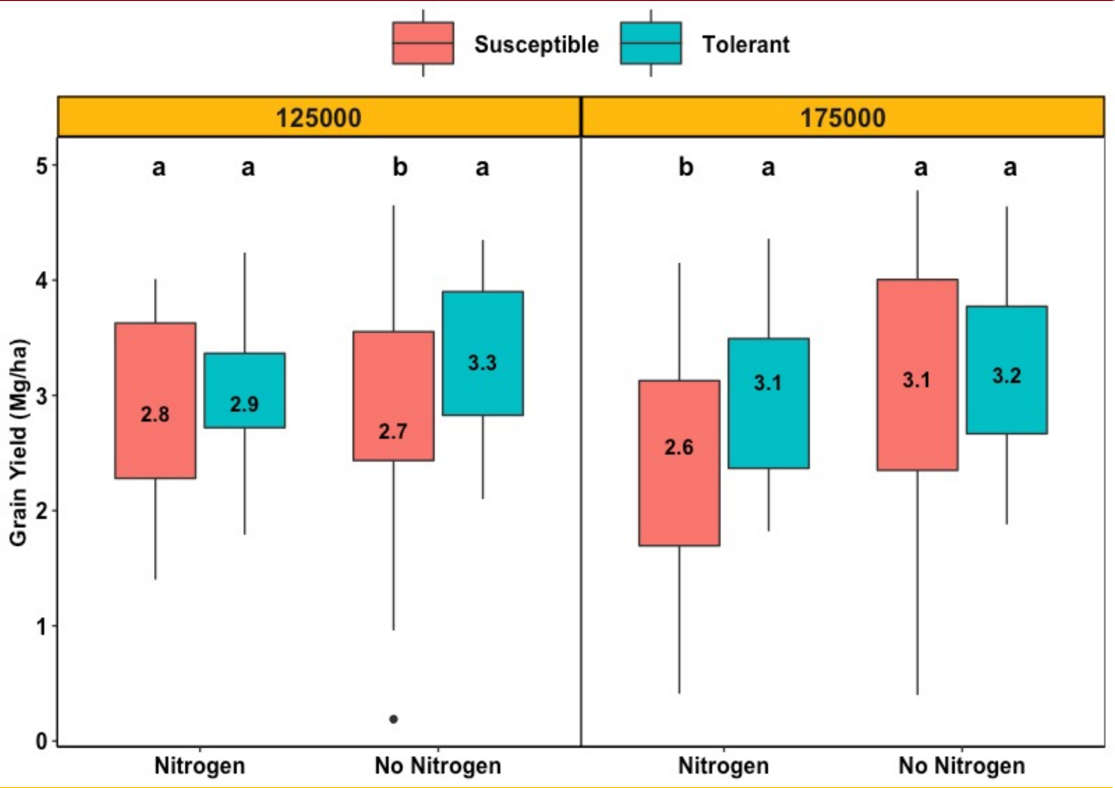

Figure 6. Soybean yield (Mg/ha) by Variety, Seeding Rate and Nitrogen application for Foxhome, MN. Letter not connected by the same color were significant at *P*<0.05 using Tukey's HSD.

At Foxhome, a three-way interaction was verified between Population, Variety and Nitrogen. A separate analysis was performed within N and Population to test for the Variety effect.

- ➢ At low seeding rates and no N application, the tolerant variety out-yielded the susceptible variety by 22%.
- ➢ The tolerant variety produced significantly more yield than the susceptible variety with increased seeding rates where N was applied.

Preliminary Conclusions

Preliminary results suggest different management strategies to be recommended depending the location and intensity of IDC.

In Neutral-Spots, where lower intensities of IDC are found, treatments have less effect on soybean yield.

In Hot-Spots, where IDC is severe, treatments varied in their effect on IDC.

Further Steps

Economic analysis ($$):

Grain Prices, Input Costs → Tradeoffs: Cost vs Yield → Recommendation: Best ROI

Model for yield prediction:

Drone Imagery & Ground-Based NDVI + IDC Symptomology: Time vs Severity → Model (Mg/ha)