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Using Data-Driven Knowledge and AI in Field Decisions

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UW Extension
University of Wisconsin-Extension

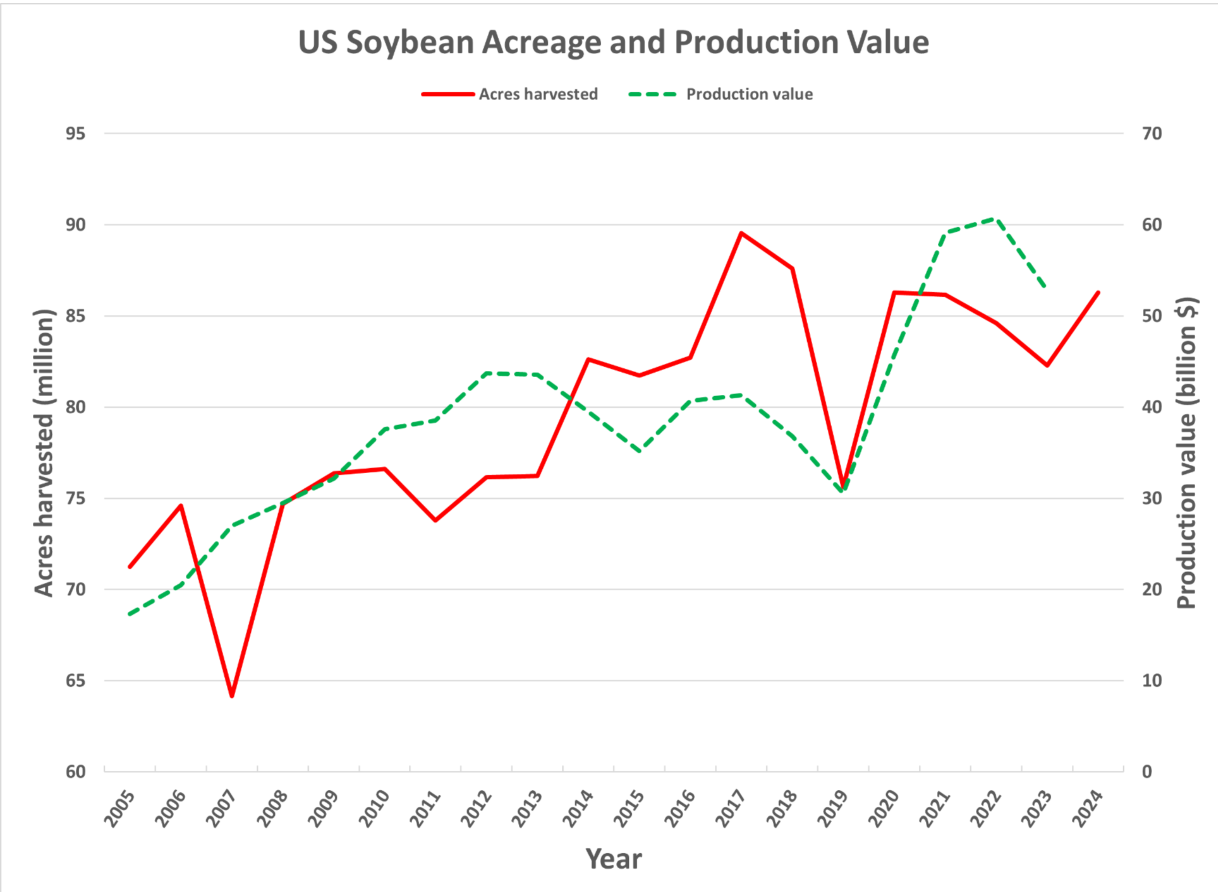
Wisconsin Soybean Marketing Board

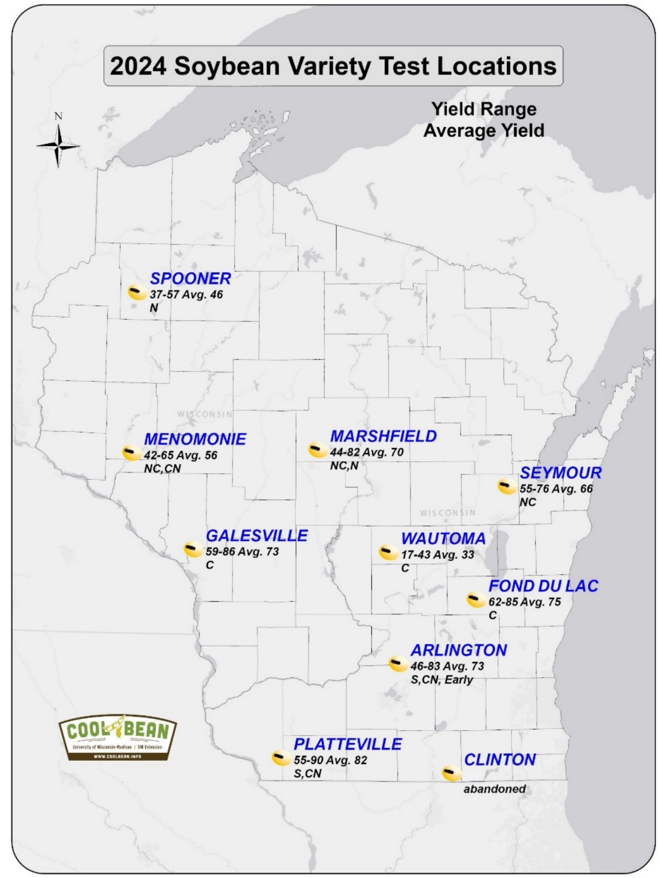
Wisconsin
University of Wisconsin–Madison

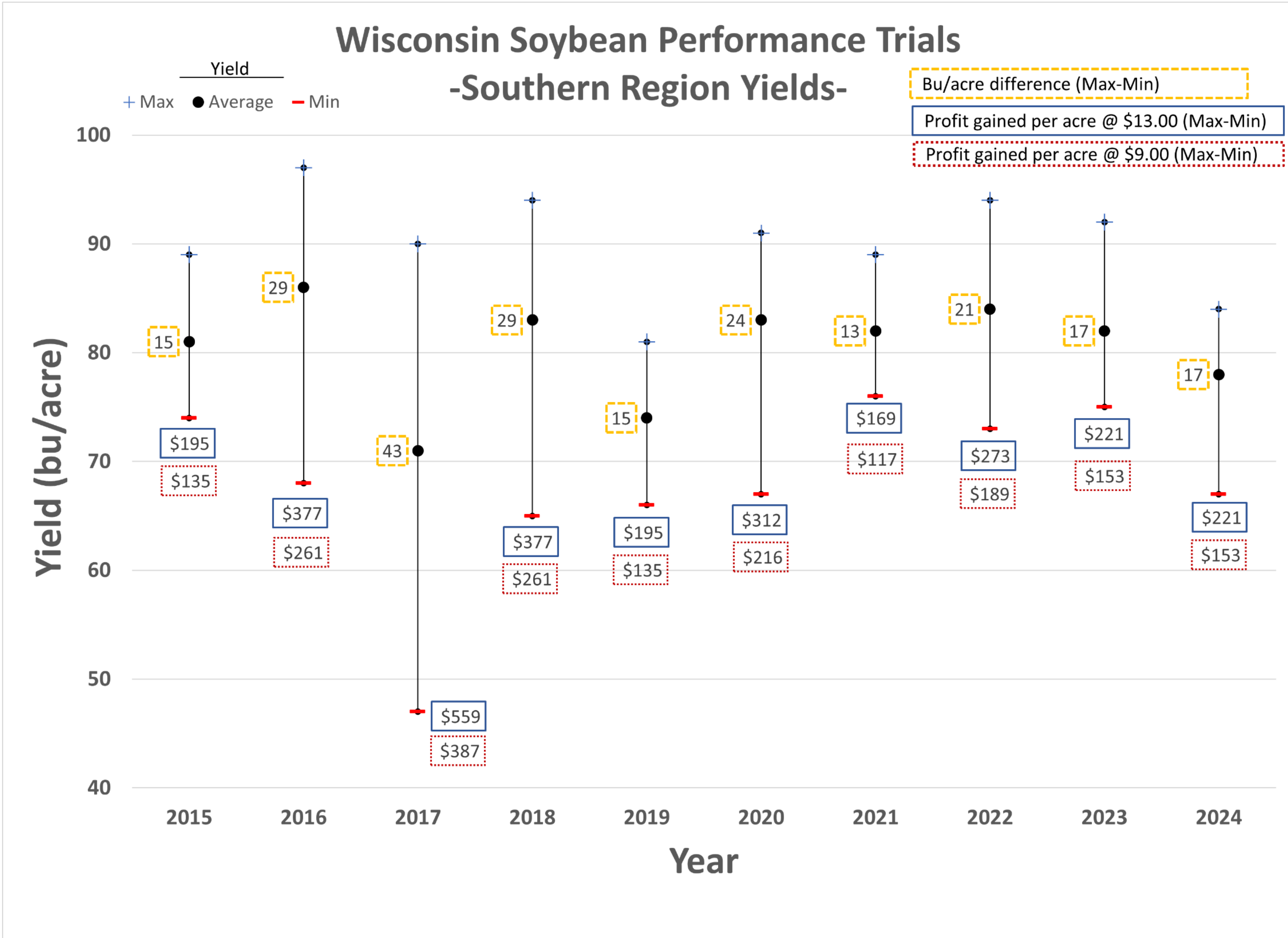
UW BeanTeam Program in Review

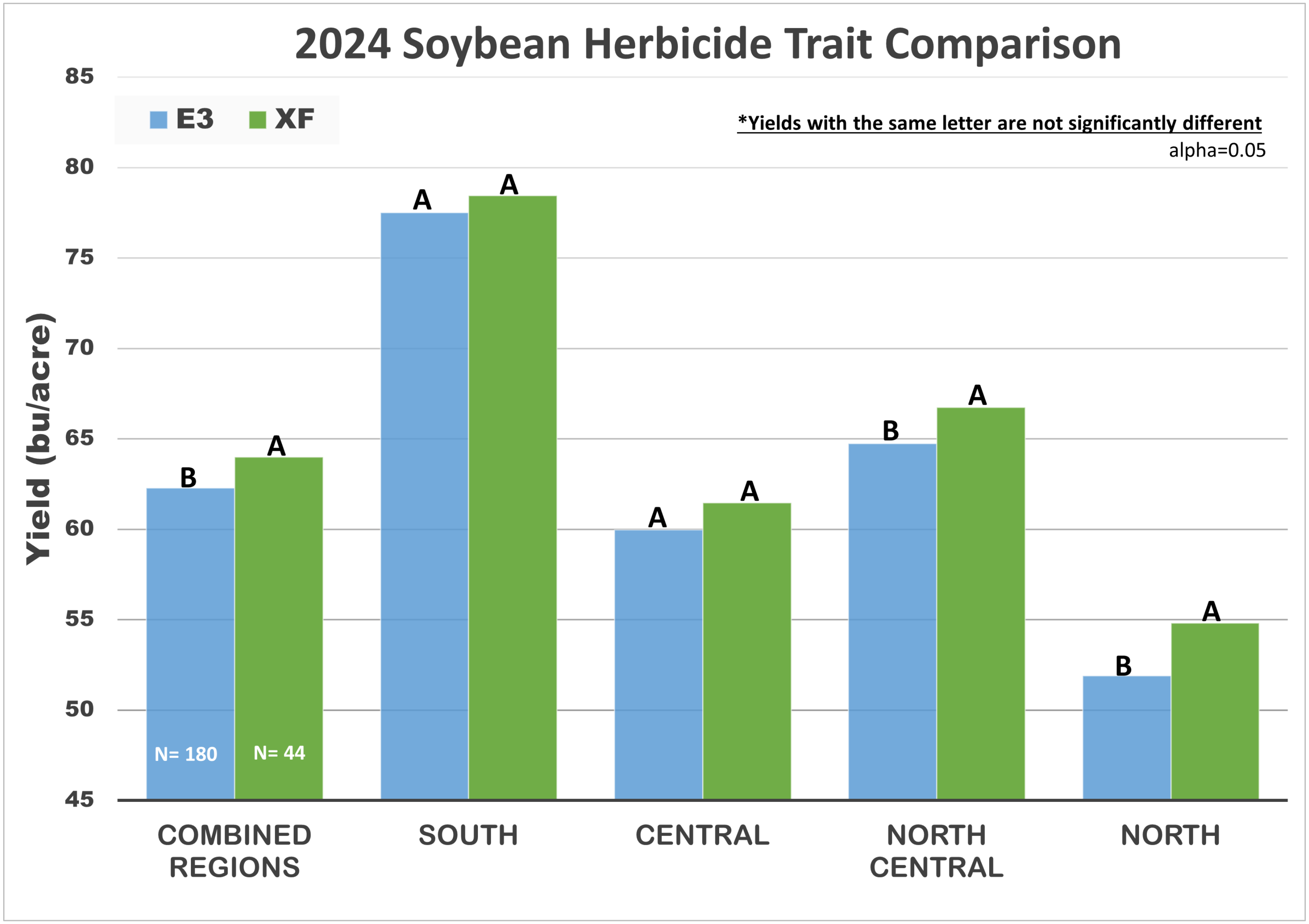
Soybean

112,360,000 bu in WI in 2024; ~$1.15B






Wisconsin Soybean Performance Trials
-Southern Region Yields-
Yield
+ Max ● Average − Min
Bu/acre difference (Max-Min)
Profit gained per acre @ $13.00 (Max-Min)
Profit gained per acre @ $9.00 (Max-Min)
Yield (bu/acre)
100
90
80
70
60
50
40
15
$195
$135
29
$377
$261
43
$559
$387
29
$377
$261
15
$195
$135
24
$312
$216
13
$169
$117
21
$273
$189
17
$221
$153
17
$221
$153
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Year


2024 Soybean Herbicide Trait Comparison
E3
XF
*Yields with the same letter are not significantly different
alpha=0.05
Yield (bu/acre)
85
80
75
70
65
60
55
50
45
B
A
A
A
A
A
B
A
B
A
N= 180
N= 44
COMBINED REGIONS
SOUTH
CENTRAL
NORTH CENTRAL
NORTH

Data Driven Challenges and Insights

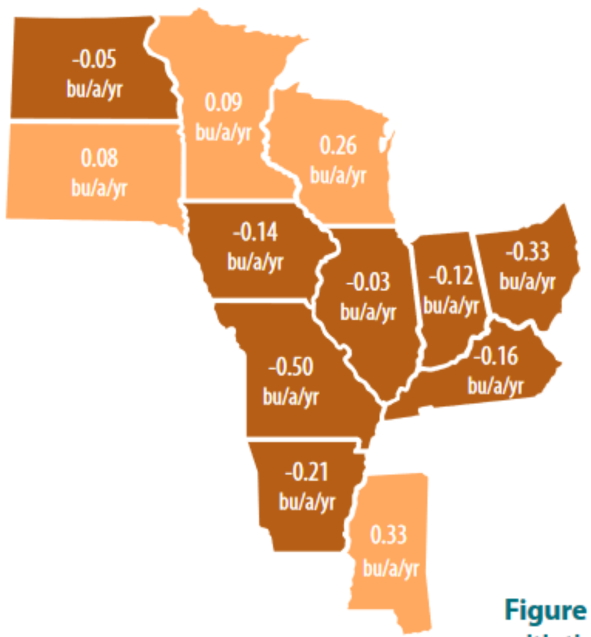
"The ability to take data – to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it – is going to be a hugely important skill in the next decades." **Hal Varian, Chief Economist, Google.**

"Data is like garbage. You'd better know what you are going to do with it before you collect it." **Mark Twain**

"There are lies, damned lies and statistics." **Mark Twain**

Climate Induced Reduction in U.S. Soybean Yield

Figure 1. Annualized yield impacts of climate-driven changes in precipitation and temperature during the past 20 years (1994-2013).



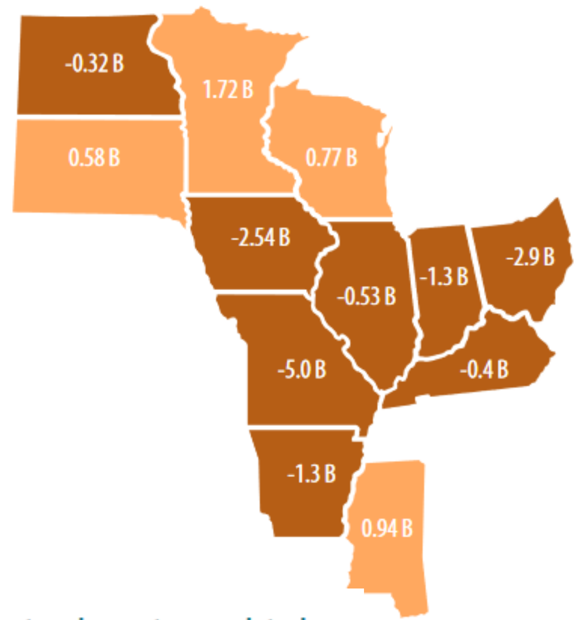


Figure 2. Monetary impacts associated with the annualized effects of changes in monthly precipitation and temperature on state-specific soybean yield trends.

The values are inflation-adjusted estimates of the dollar value (in billions of 2013 dollars) and reflect the impacts over the 20-year period 1994 to 2013.

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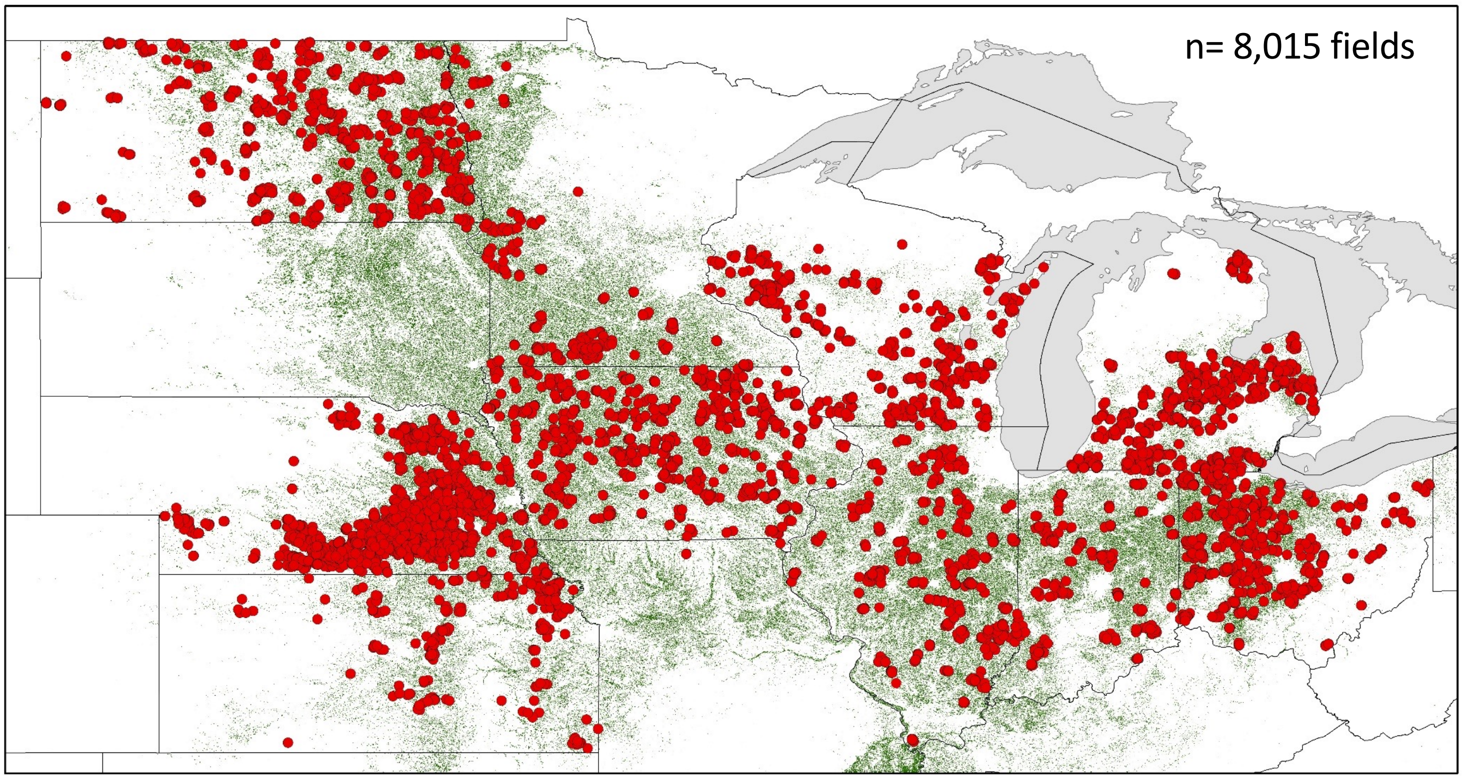
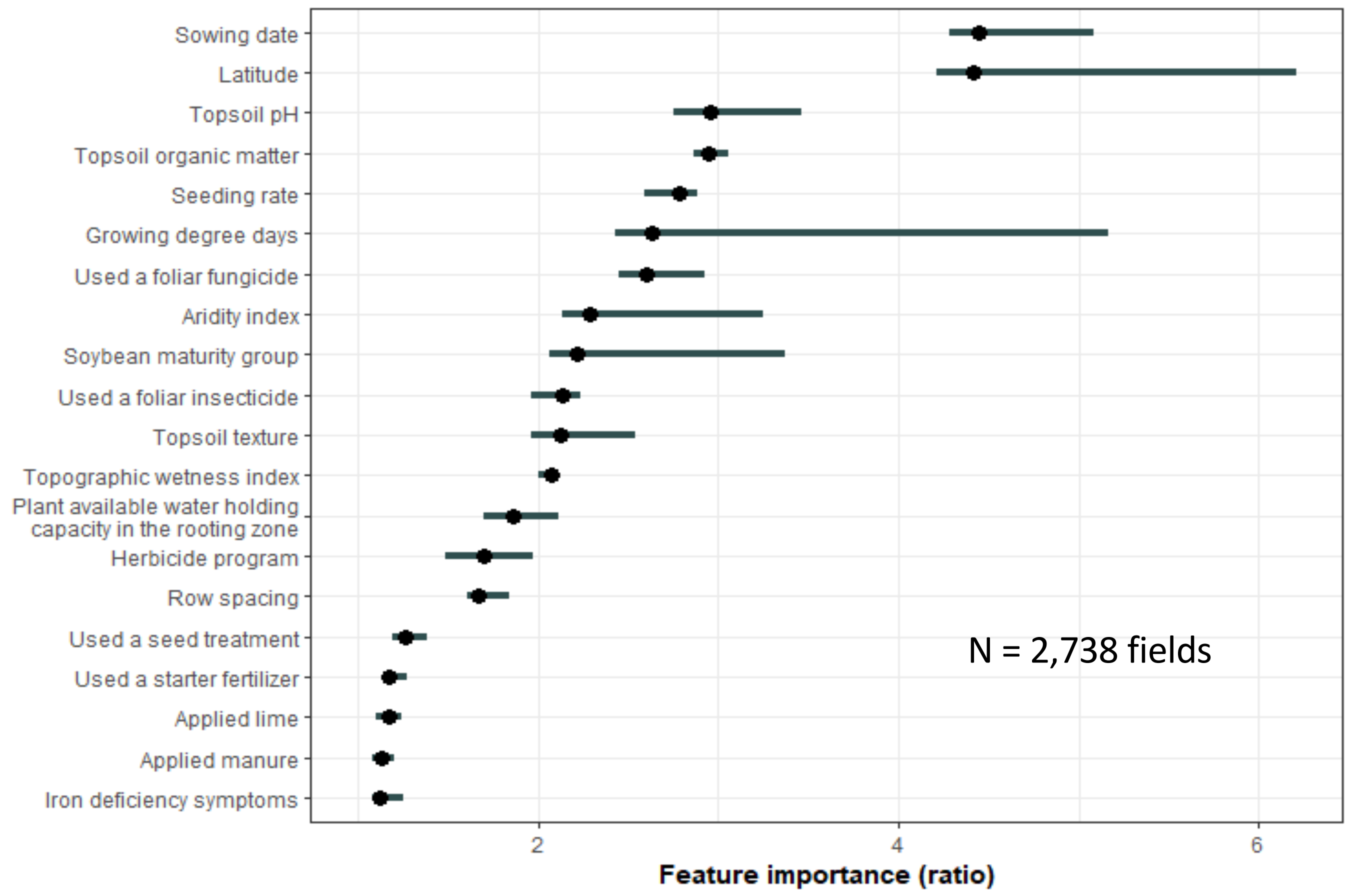
Boots on the Ground On-Farm Validation

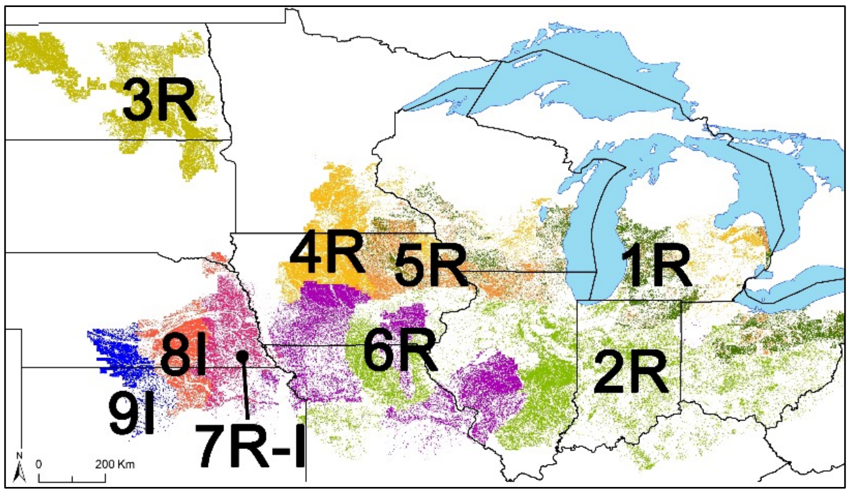


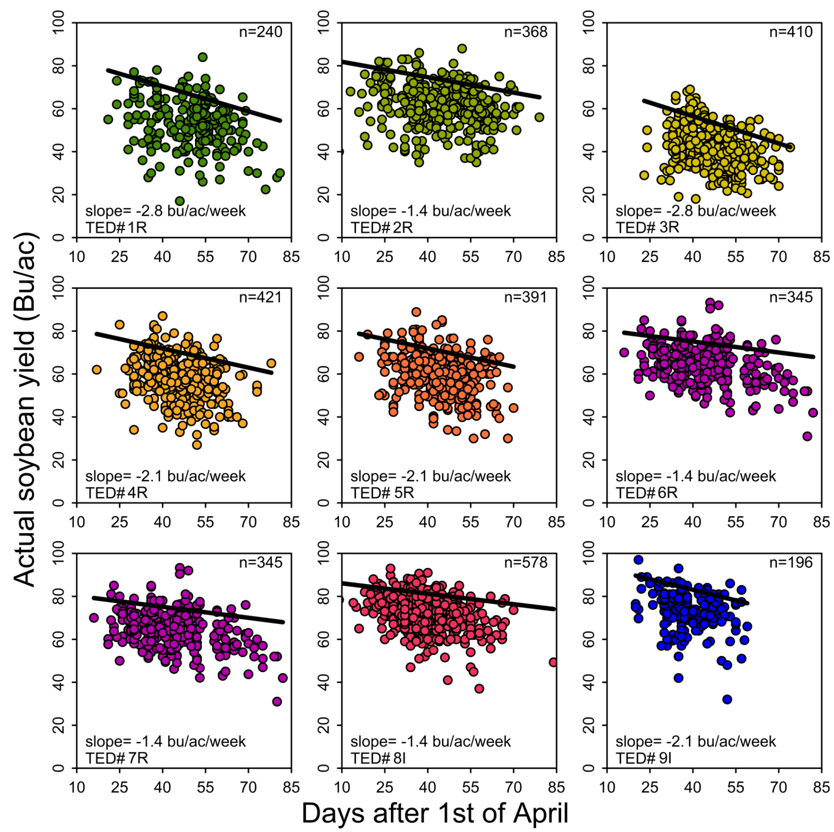
Importance of management-based variables in a random forest model predicting soybean yield.

Shah, A.D., T. R. Butts, S. Mourtzinis, J. I. Rattalino Edreira, P. Grassini, S. P. Conley and P. D. Esker. 2021. An interpretable machine learning assessment of foliar fungicide contribution to soybean yield in the north-central United States. Scientific Reports 11:18769. https://doi.org/10.1038/s41598-021-98230-2.



Influence of planting date on soy yield by TED

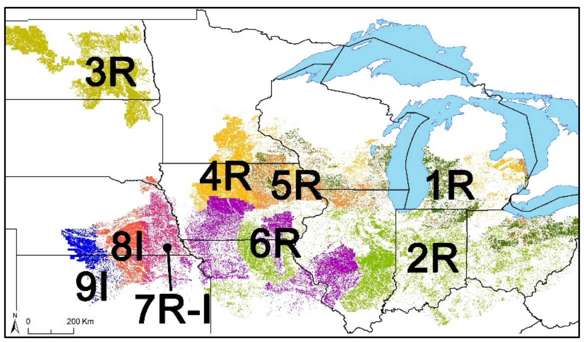


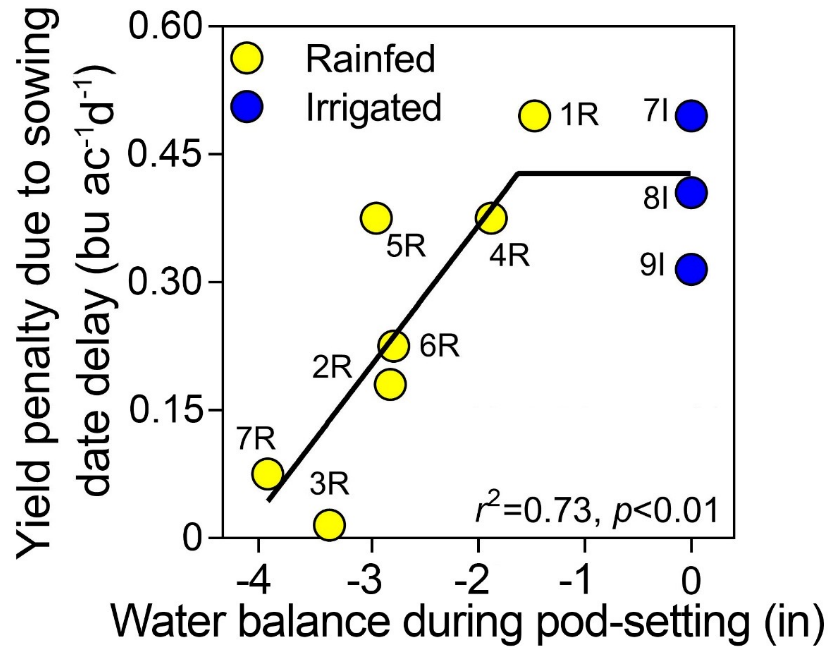


(Rattalino Edreira et al. 2017a,
Agric. For. Meteorol. 247, 170-180)

Water deficit influence in potential response to planting date

Yield penalty (or response) to sowing date was negligible when water deficit was < -4 in, but increased linearly up to nearly ~1 in

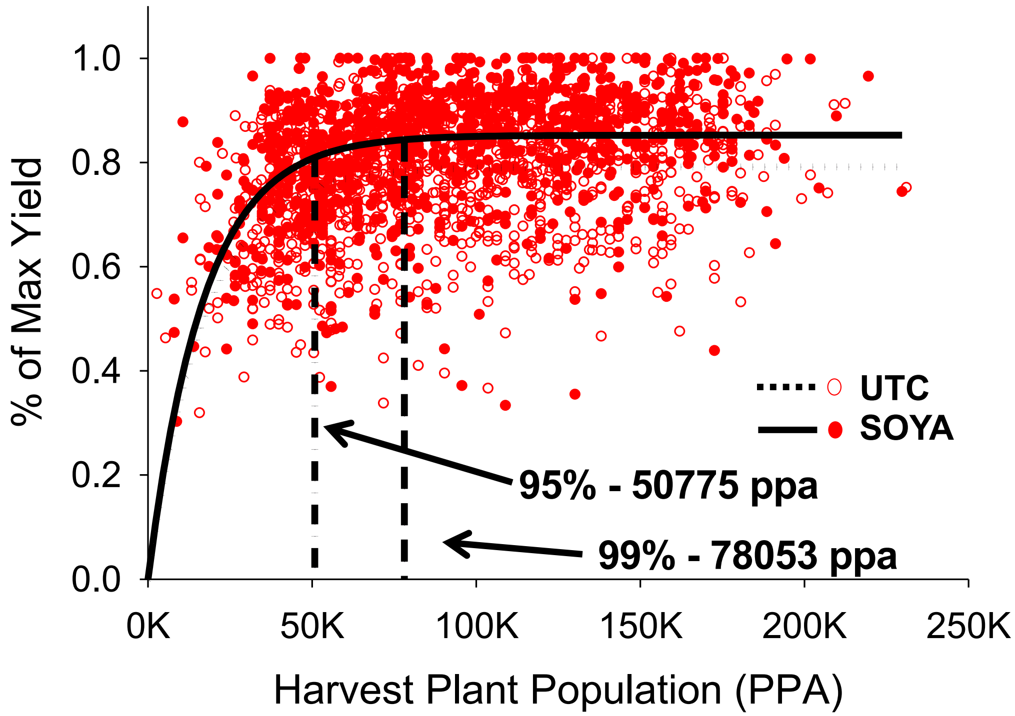


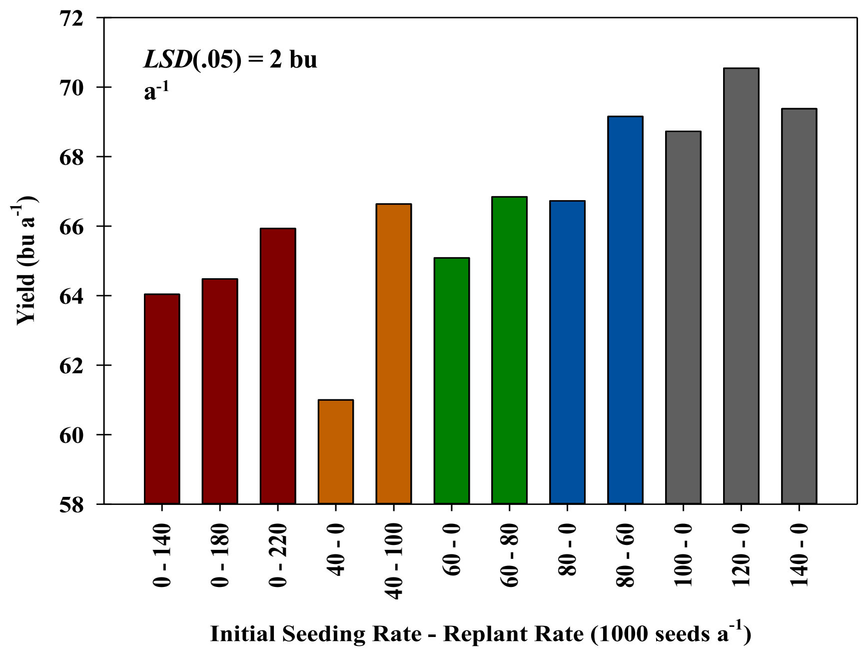


(Rattalino Edreira et al. 2017a, Agric. For. Meteorol. 247, 170-180)

Soybean harvest population and yield resilience

2012-2014 Average Yield Env. (43 Envs.)





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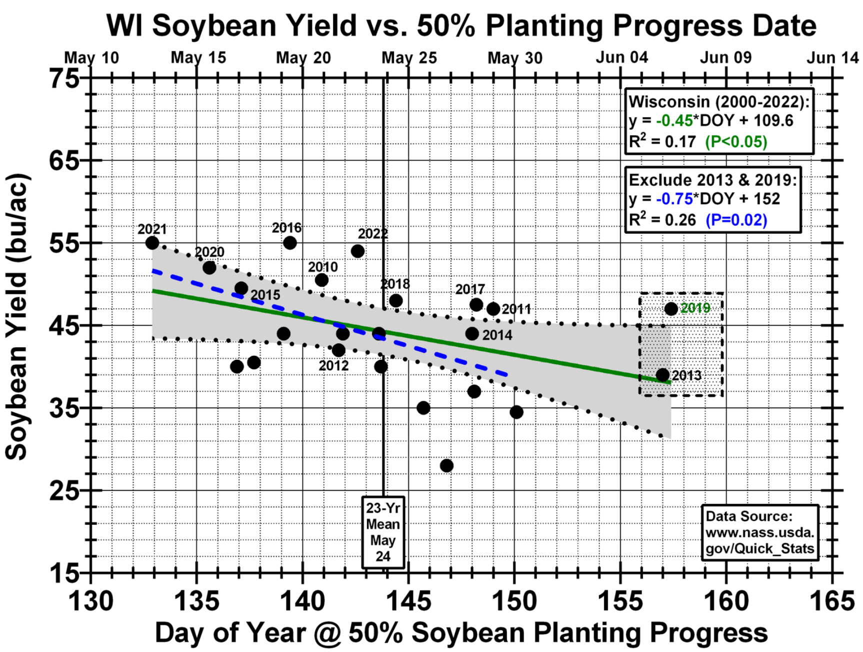
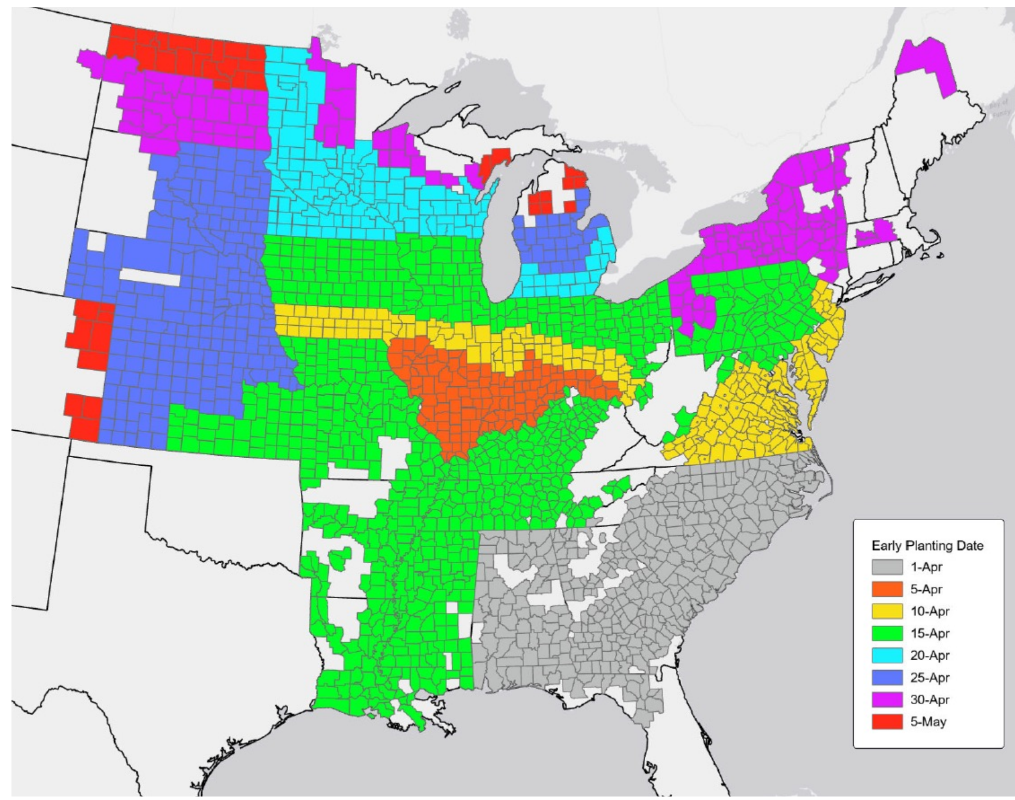
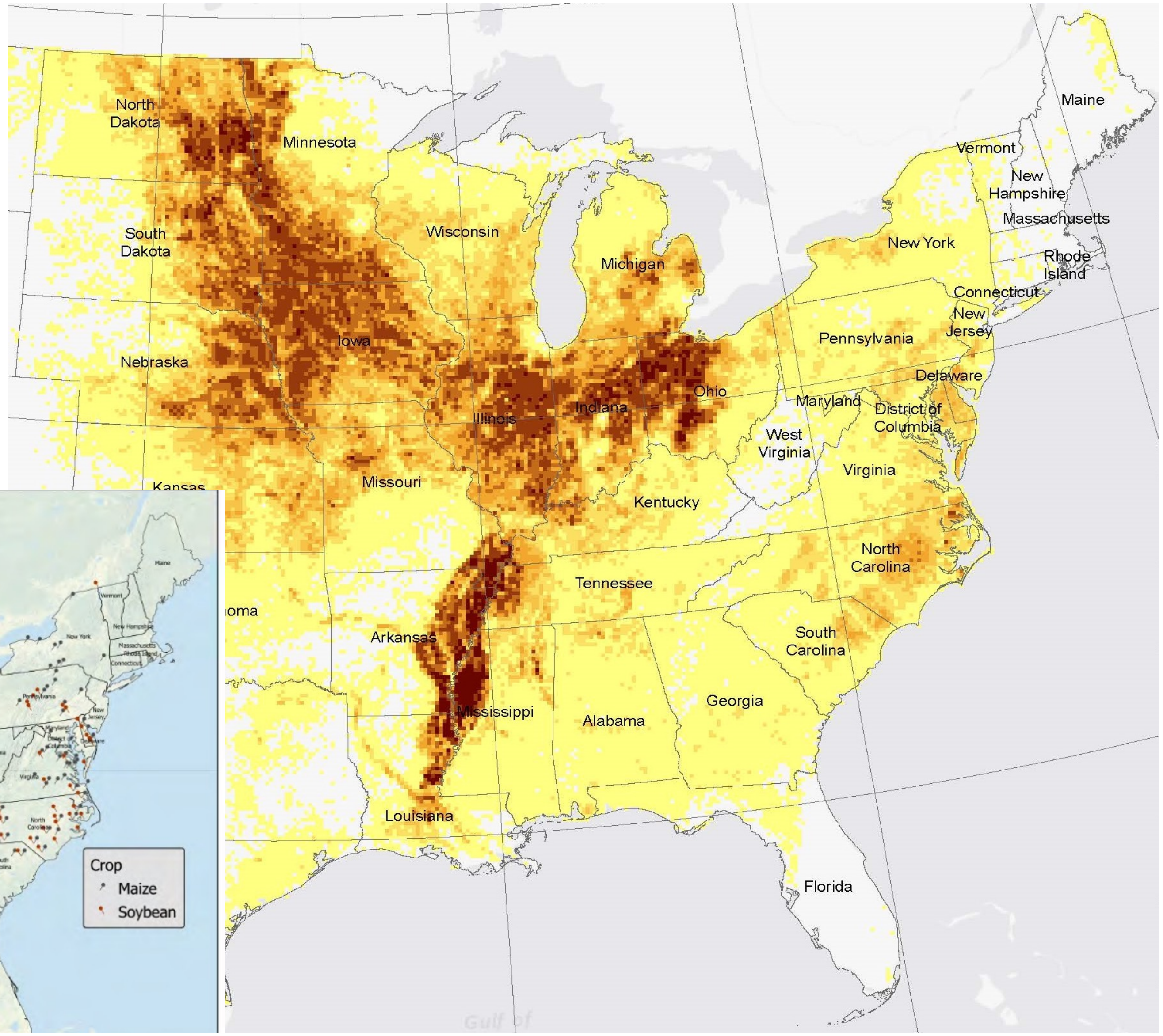
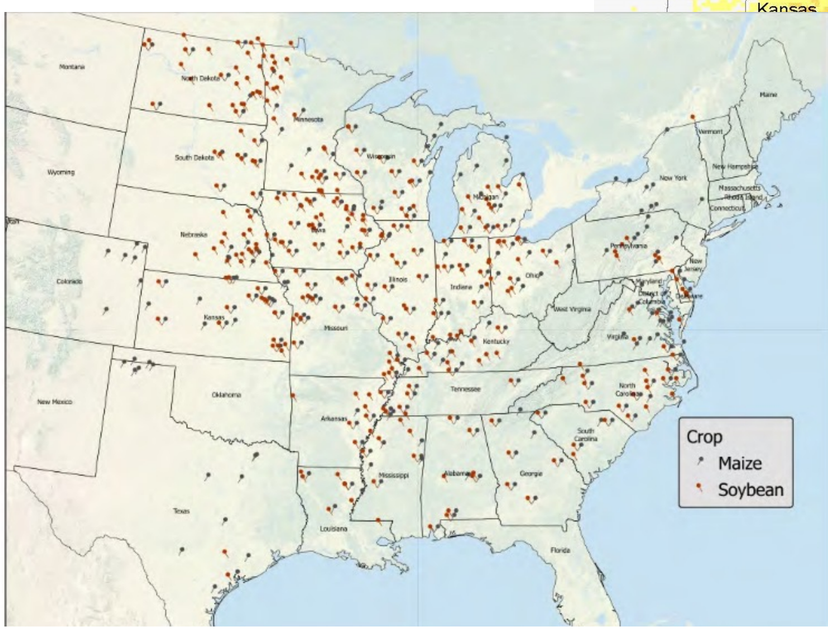
- Informed policy changes
  - Updated RMA replant coverage





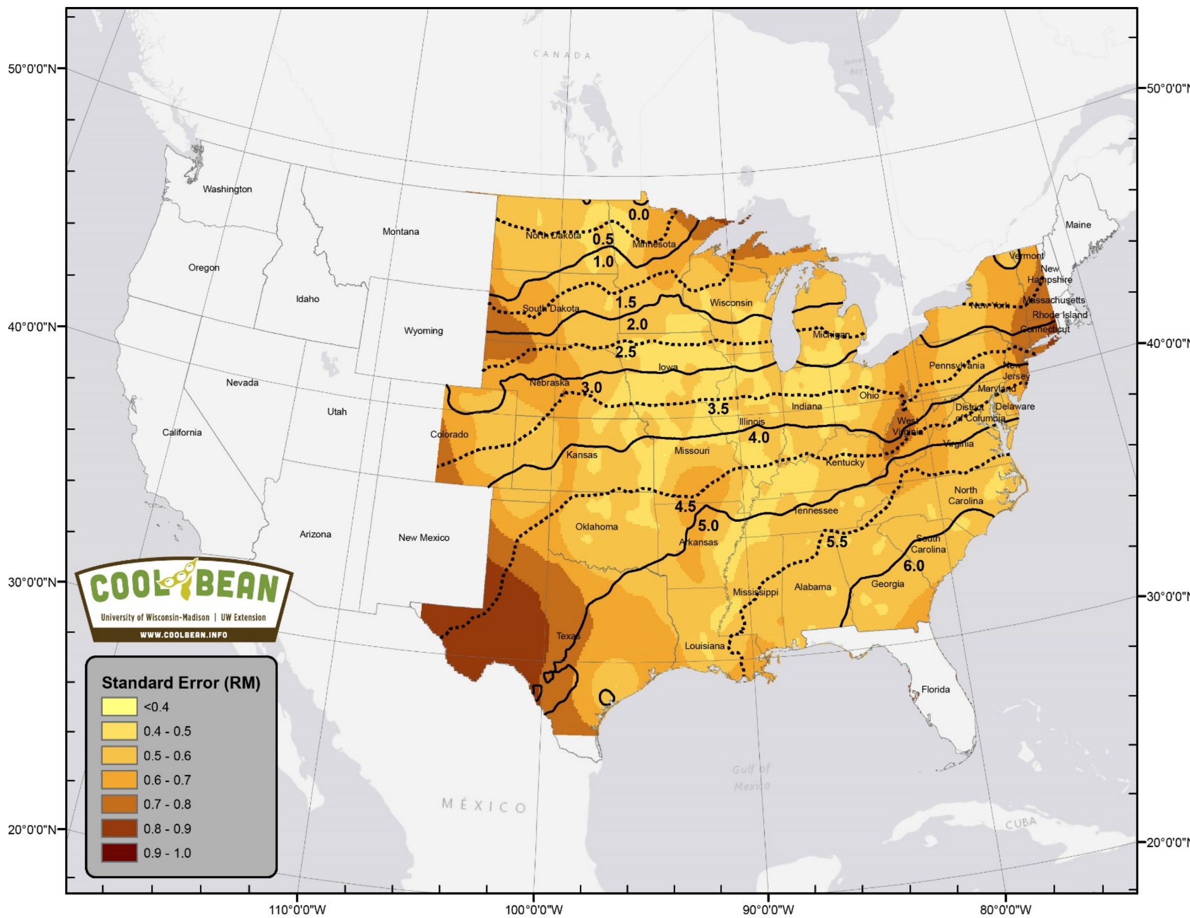
The spatial coverage of our database is extensive and coincide with the region where most of corn and soybean are grown across the US





Big Data Can Lead to Grounded Insights

- “Errors using inadequate data are much less than those using no data at all.” **Charles Babbage, inventor and mathematician.**
- “Without data you’re just another person with an opinion.”**Edwards Deming, Statistician**

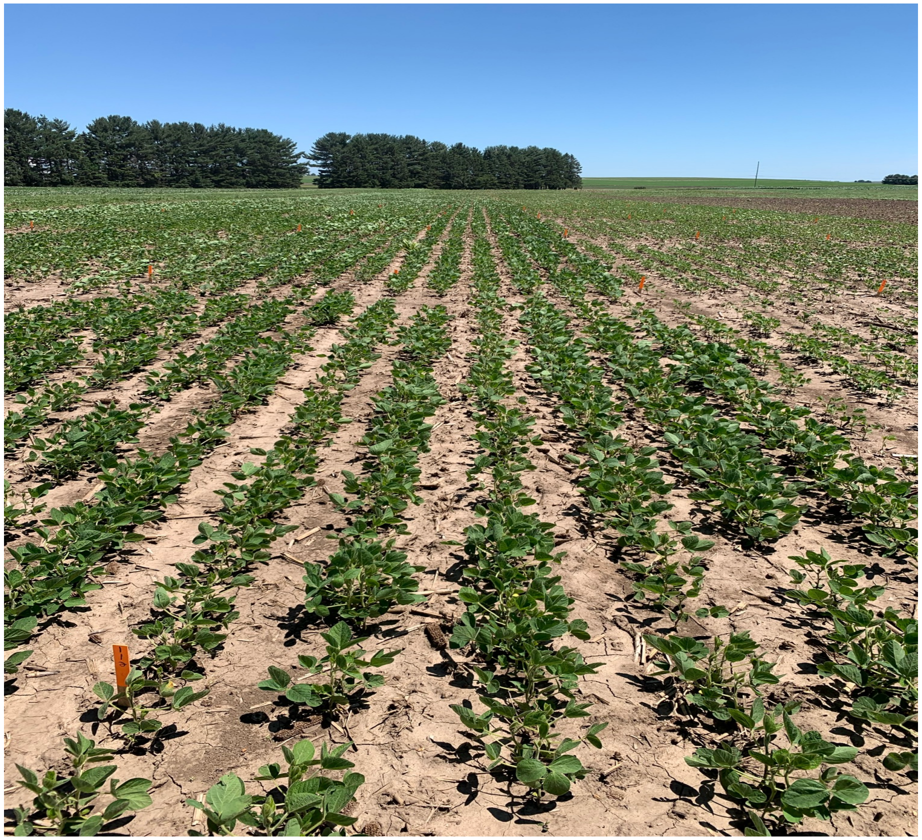


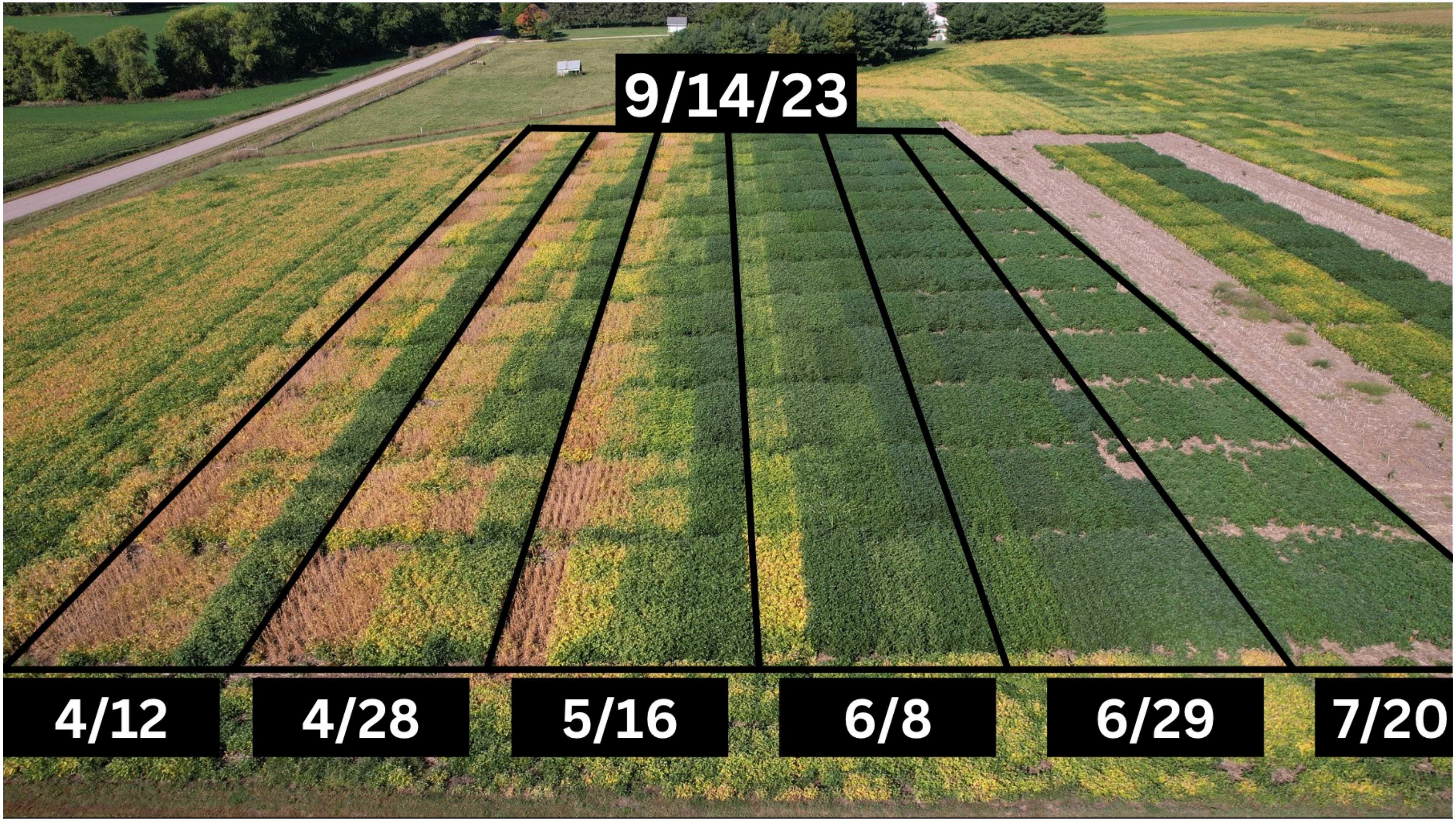
Methods – Planting Date x Maturity Group

- Conducted at the Arlington Research Station in Arlington, Wisconsin

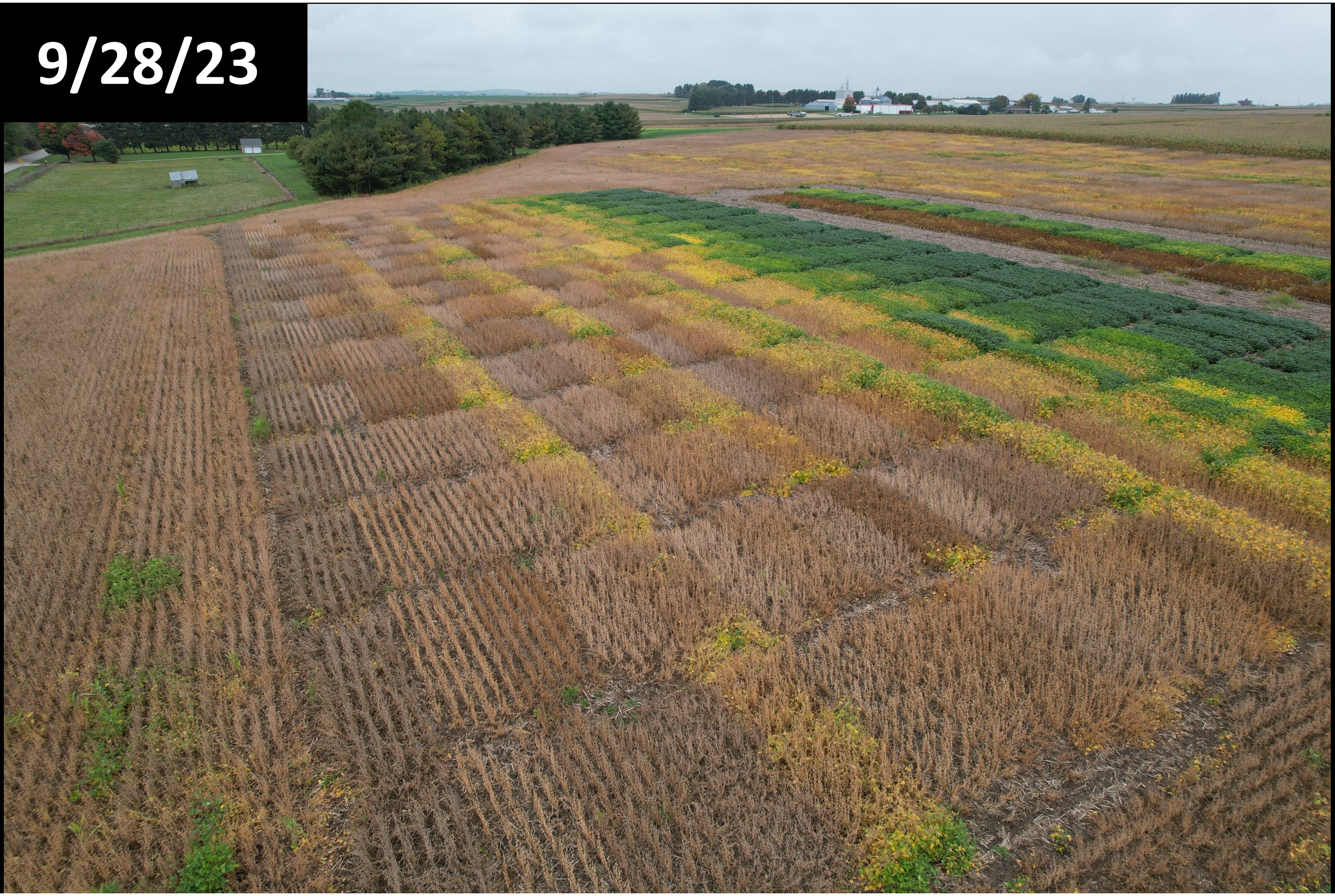
- Randomized Block Split Plot Design
  - Whole plot: 5 to 6 soybean planting dates
  - Split plot: Maturity Groups ranging from 0.3 - 2.9
- 15" rows and 140k seeds/acre seeding rate

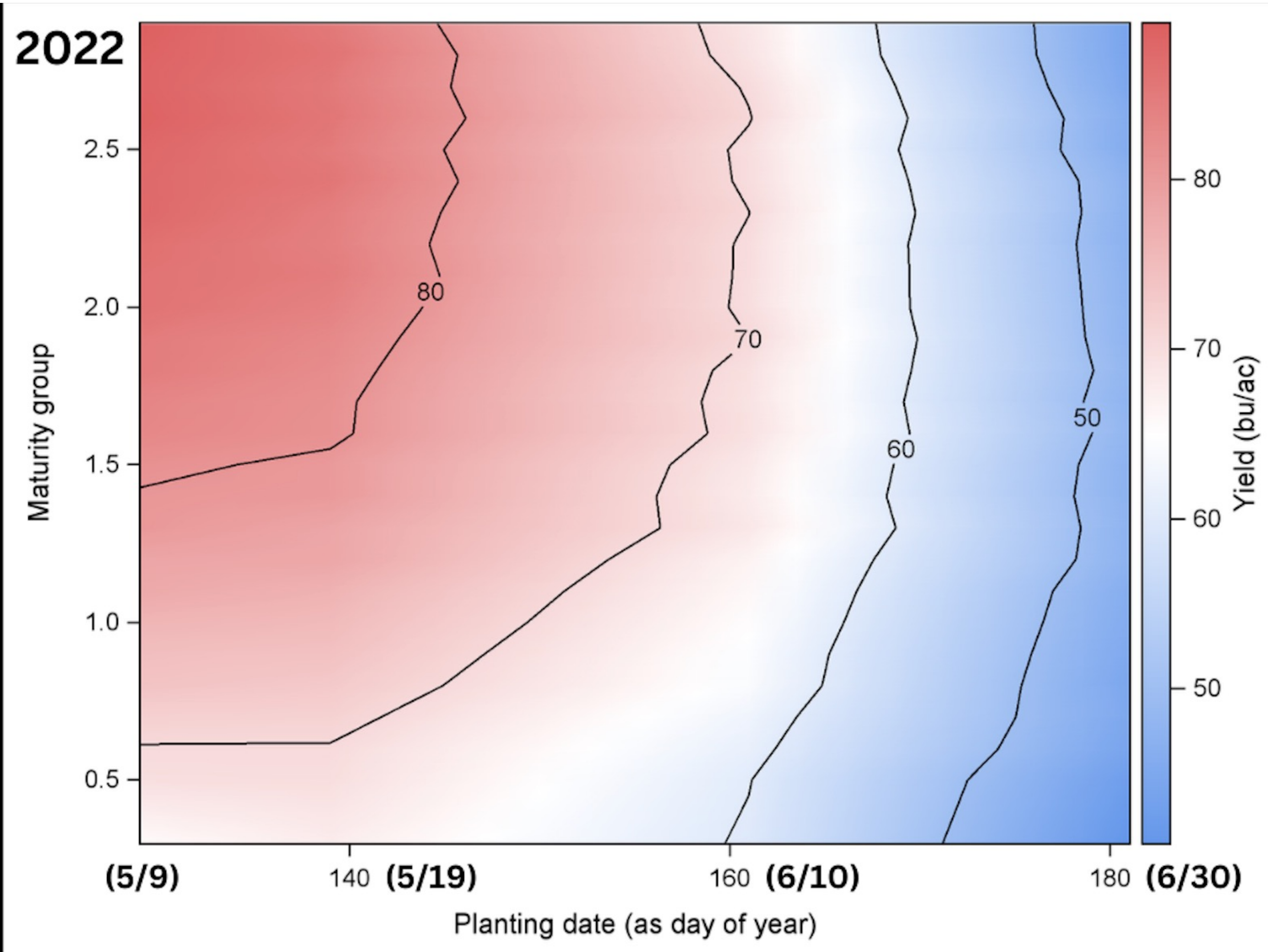
- Plot size: 7.5' wide x 25' long



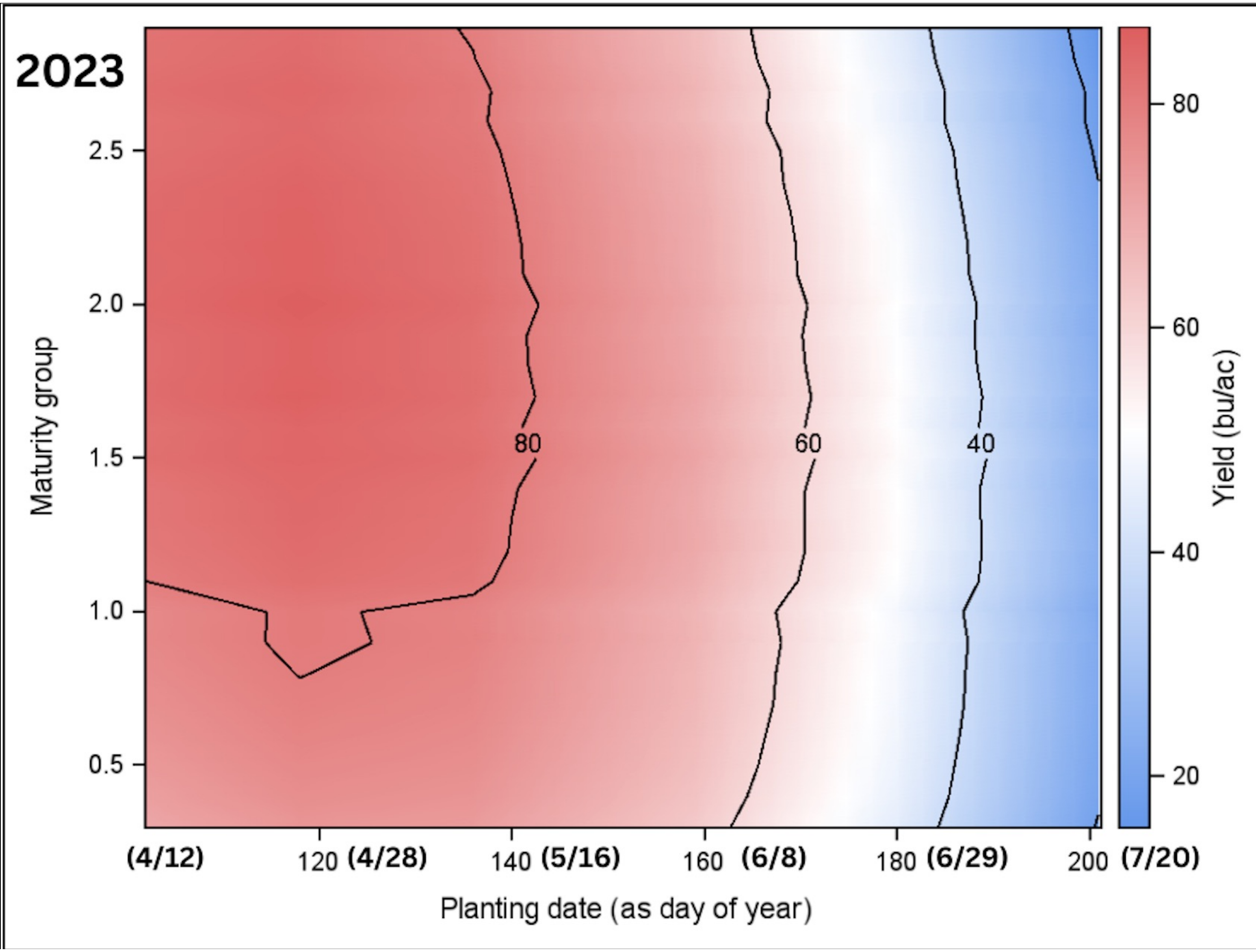

9/14/23
4/12
4/28
5/16
6/8
6/29
7/20

9/28/23





2022
Maturity group
2.5
2.0
1.5
1.0
0.5
80
70
60
50
Yield (bu/ac)
80
70
60
50
(5/9)
140
(5/19)
160
(6/10)
180
(6/30)
Planting date (as day of year)

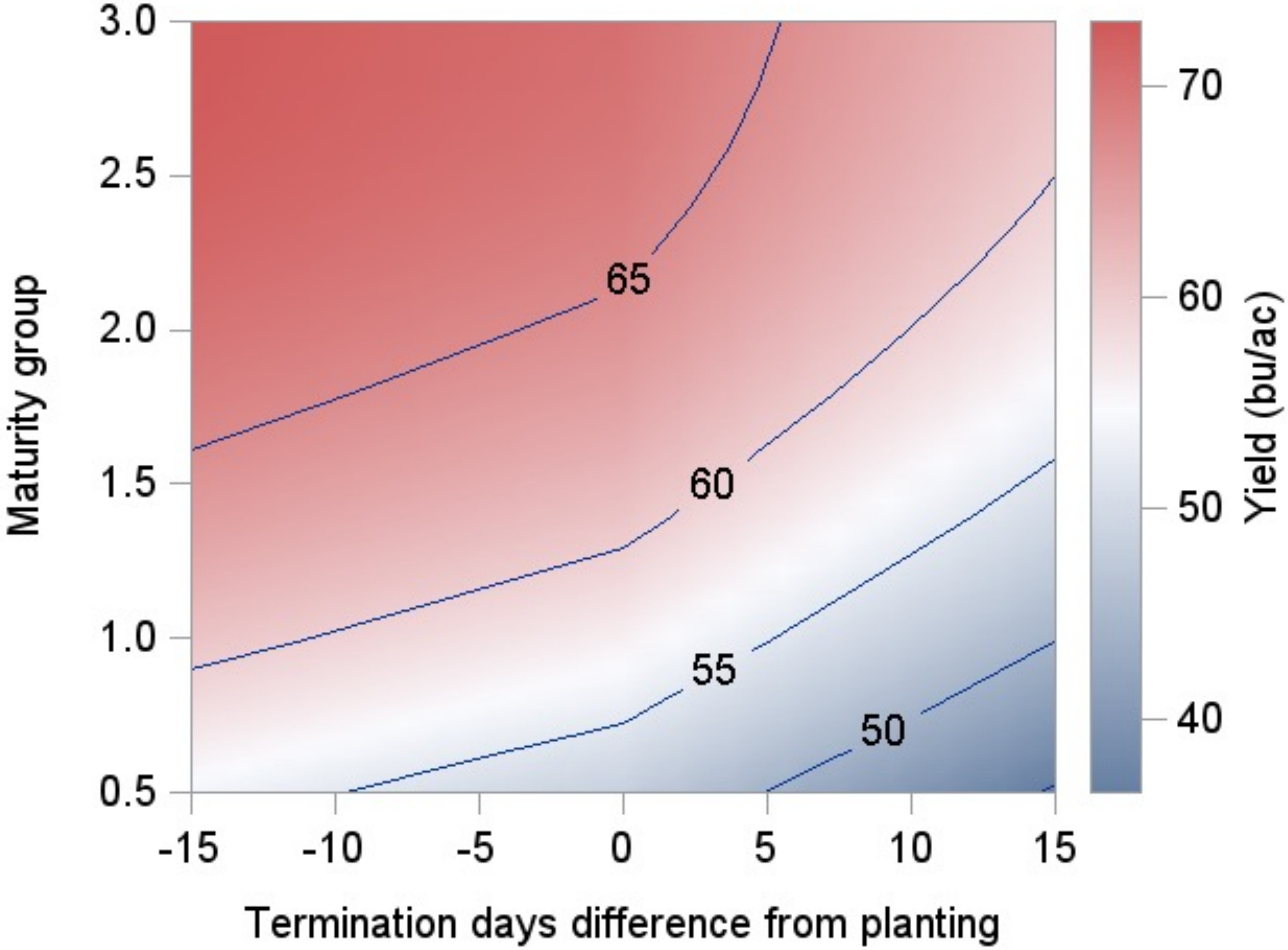


2023
Maturity group
2.5
2.0
1.5
1.0
0.5
80
60
40
120
140
160
180
200
(4/12)
(4/28)
(5/16)
(6/8)
(6/29)
(7/20)
Planting date (as day of year)
Yield (bu/ac)
80
60
40
20

MG x CC Term

Methods

- One location: Arlington, Wisconsin
- Experimental design: RCBD split-plot
- Statistical analysis conducted using SAS 9.4
- Previous crop: corn silage
- Tillage: no-till
- Rye planting information:
  - Date: Sept. 30, 2023
  - Variety: Spooner
  - Seeding rate: 60 lb/ac
- Soybean planting information:
  - Date: May 6, 2024
  - Seeding rate: 140k seeds/ac
  - Row spacing: 30 inches
- Whole plot (WP) treatments:
  - -Rye termination timings (3)
  - PP: 2 weeks prior to planting
  - ATP: At soybean planting
  - POST: 2 weeks after planting
- Rye terminated with glyphosate
- Split-plot (SP) treatments:
  - -Soybean variety/MG range (14)
  - MG 0.5-2.9



- Planting early + later maturity groups = higher yields
- Important to select high-yielding varieties within MGs
- Soybean yield declined when planted after May 20th
- 2023 Maximum Yield was observed by planting on April 28th with a 2.0 Maturity Group
- If you delay CC termination plant a longer MG bean

Importance of management-based variables in a random forest model predicting soybean yield.

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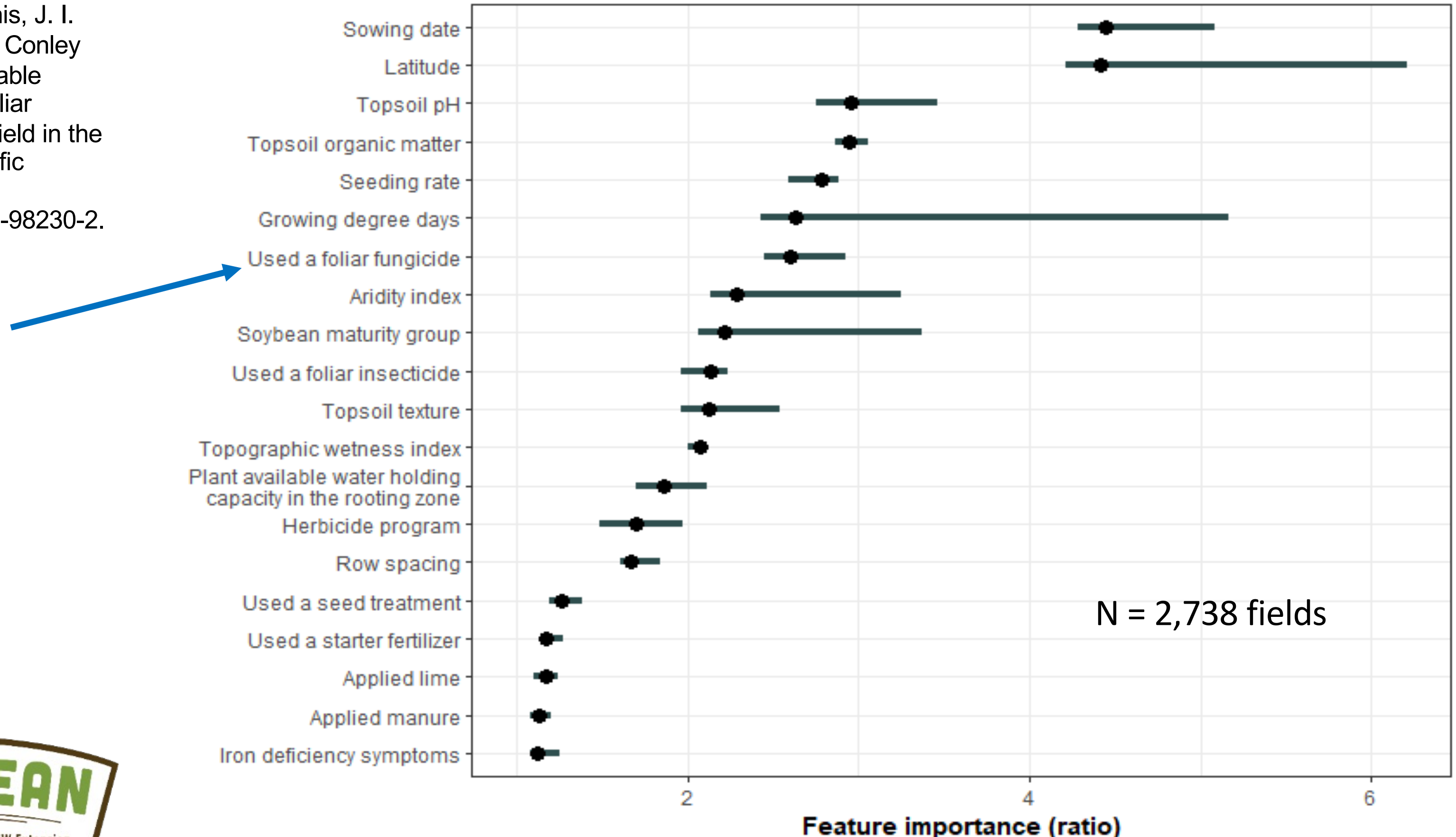

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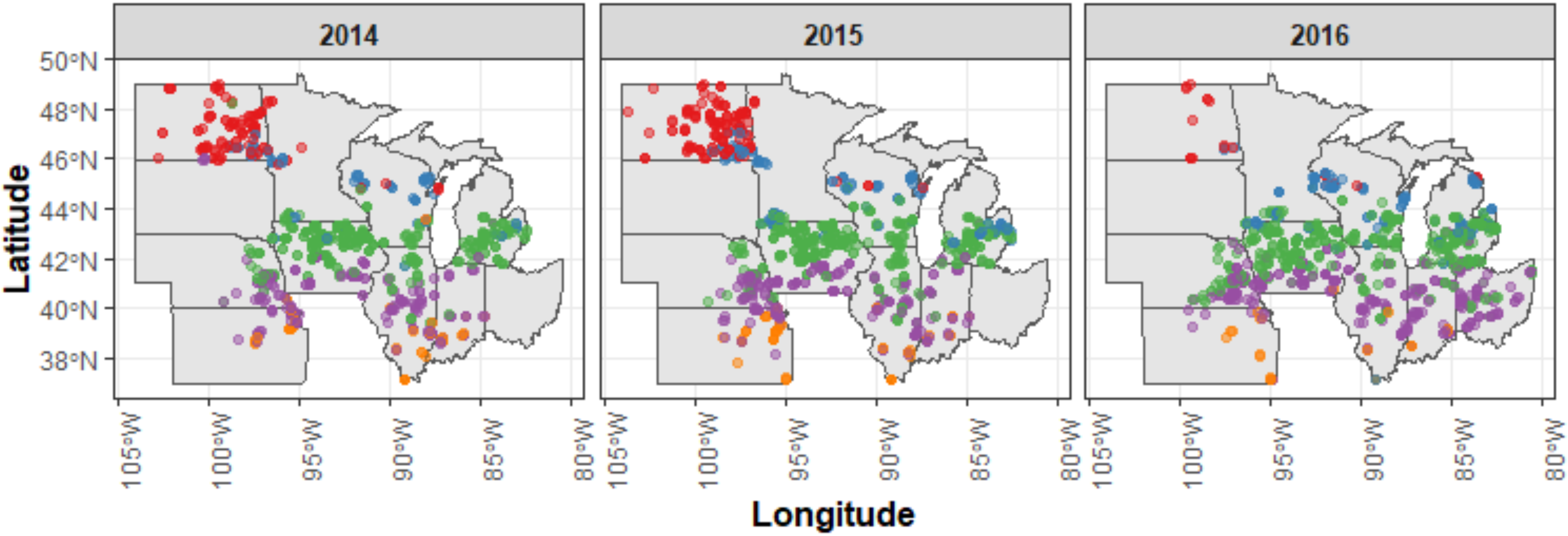

Locations of soybean fields for which surveyed growers supplied self-reported data on their management practices and yields, 2014 to 2016. Field locations are colored by soybean maturity group.

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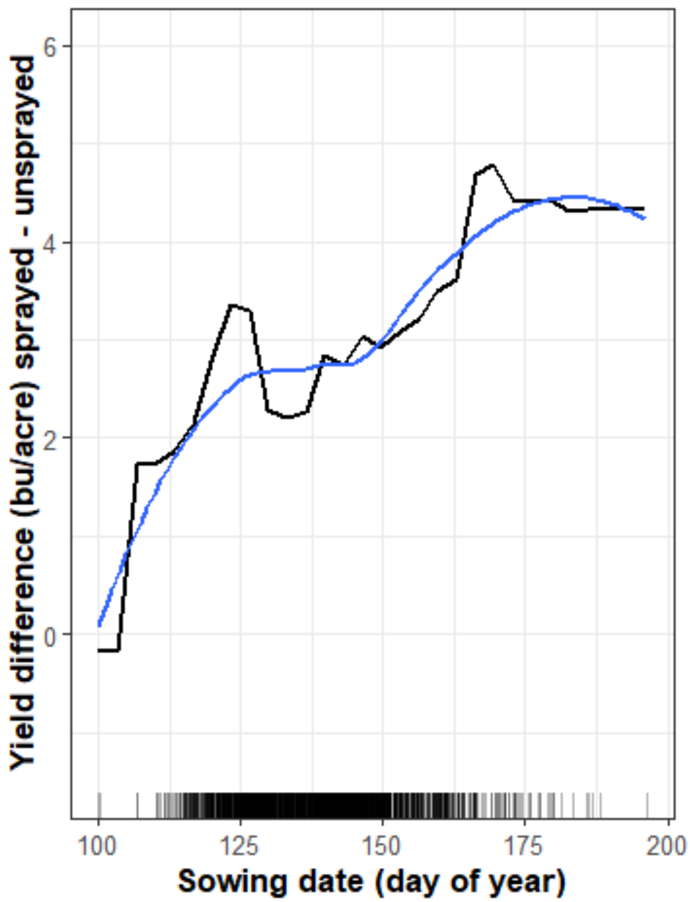
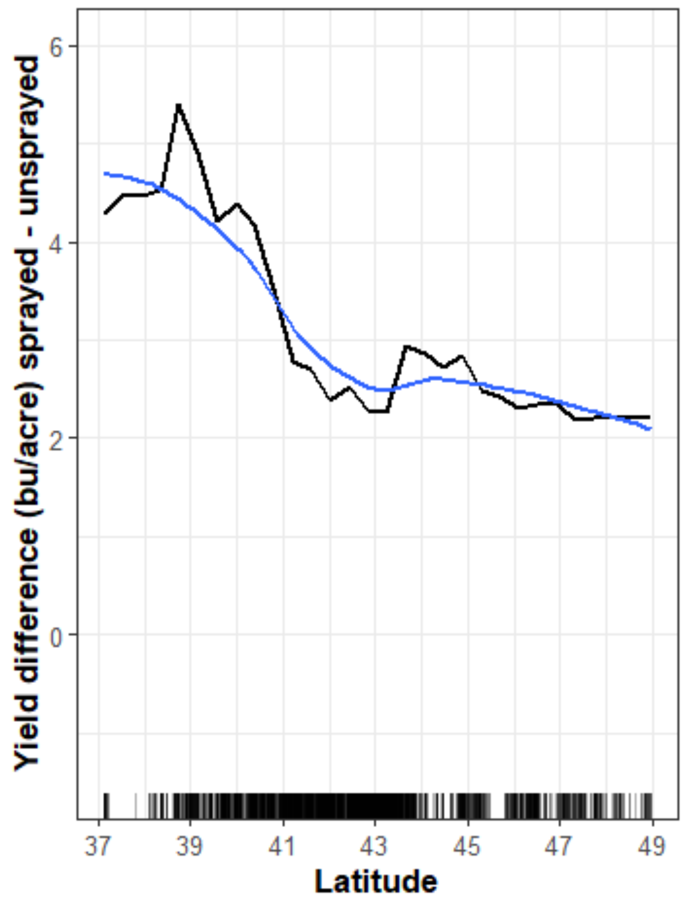
Results *cont.*

Two-way partial dependence plots of the global effects of (i) foliar fungicide use and sowing date (left panel), and (ii) foliar fungicide use and latitude (right panel) on soybean yield. The black plotted curves are the yield differences between fields that were sprayed or not sprayed with foliar fungicides.



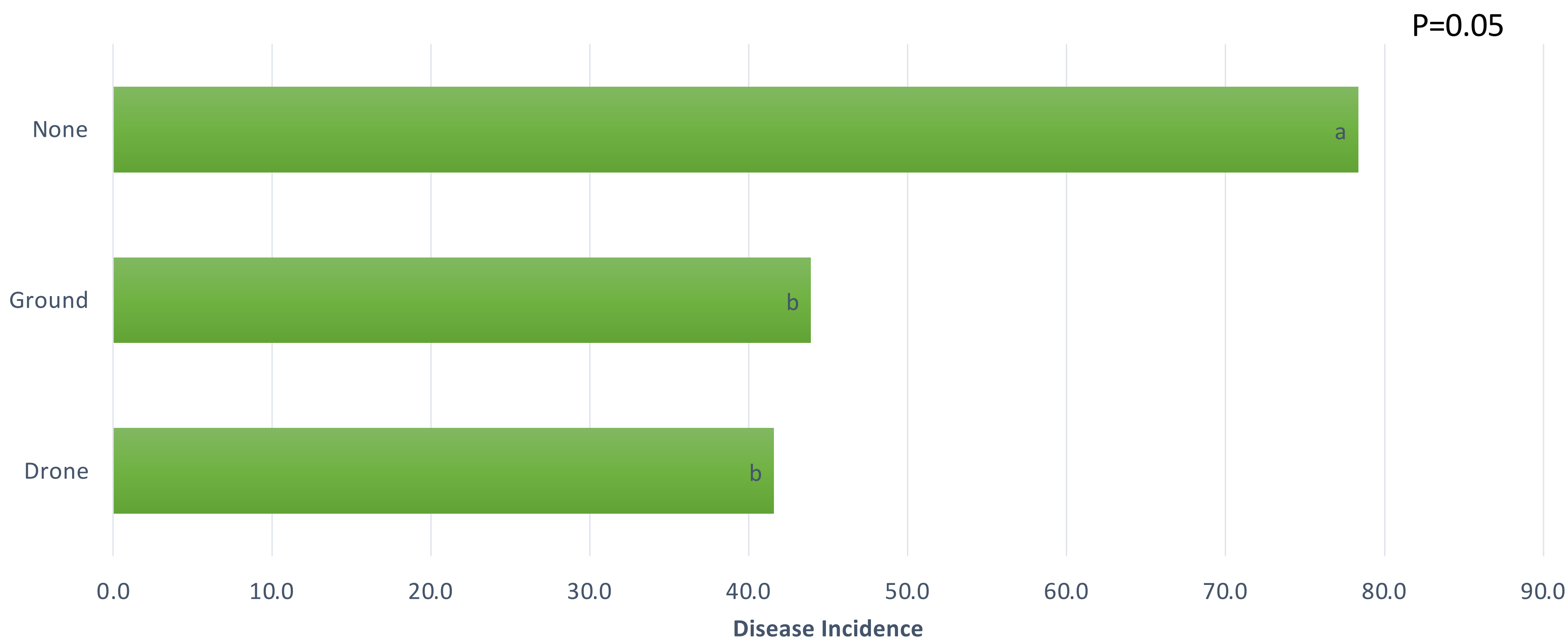


2023 Drone Large-Plot Trial

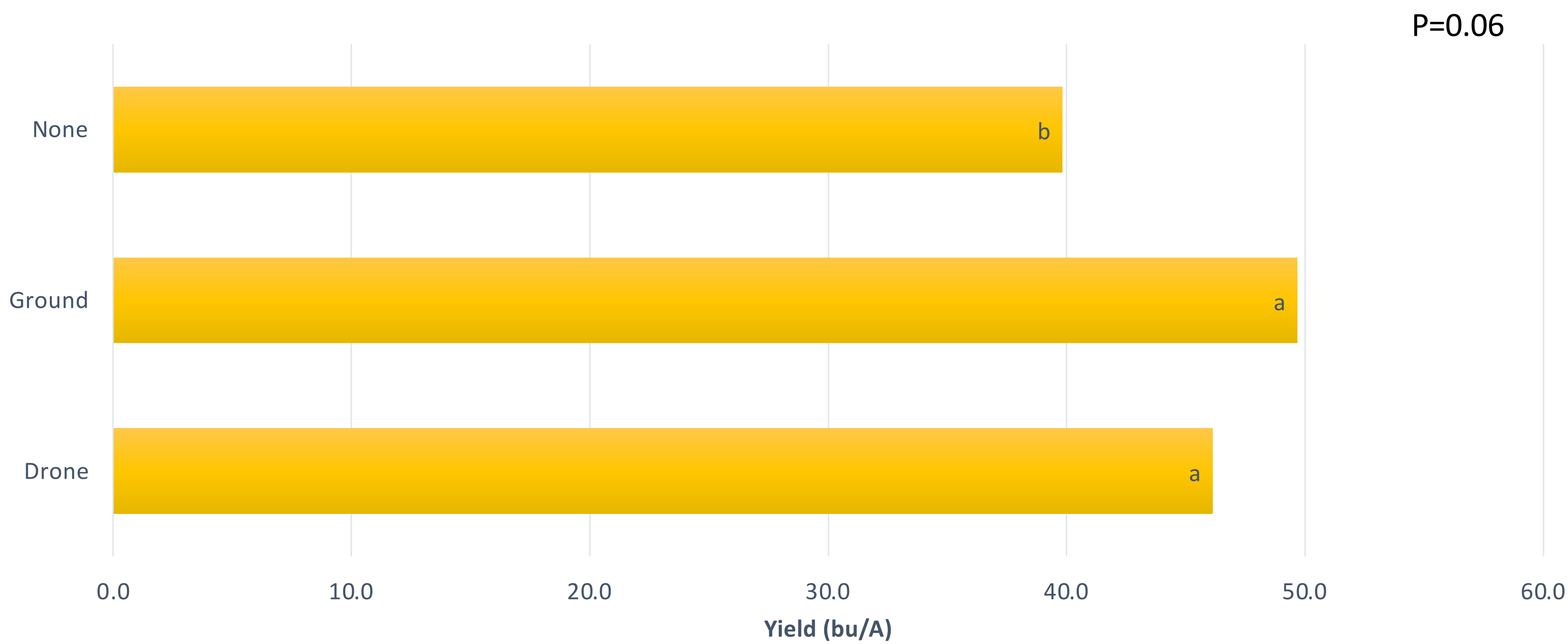
- Arlington ARS
- Field with a history of white mold
- Seeded at 160K
- 15" row-spacing
- 4 blocks (reps)
  - -Non-treated check
  - -Ground application @ 15 GPA (Endura 8 oz/A; R3)
  - -Drone application @ 2 GPA (Endura 8 oz/A; R3)
- Each Plot was 90' x 325'
- Yield from commercial combine
- We thank the WI Soybean Marketing Board for Support!

Disease Incidence and Visual Damage

Disease Incidence



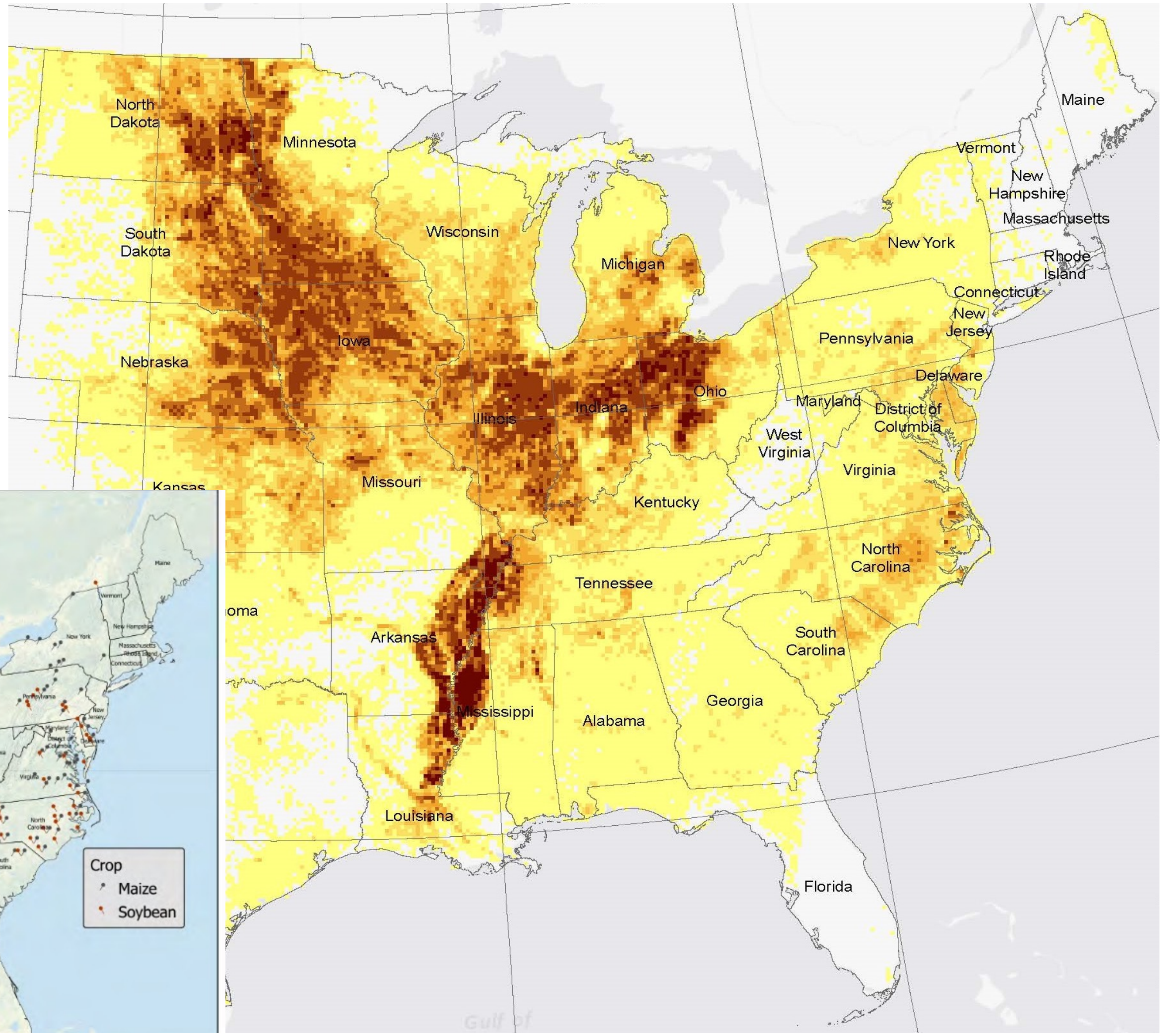
Yield

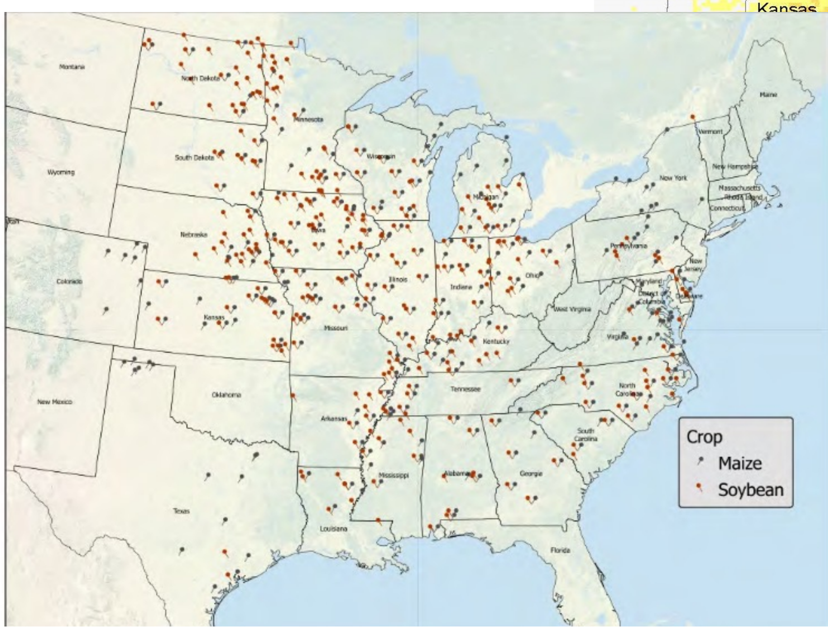

P=0.06
None
Ground
Drone
b
a
a
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Yield (bu/A)

The Take Home

- Technologies that might help
  - -Fungicides; Download the Sporebuster app to find the products with the best ROI
  - -Use Sporecaster to help determine when to spray and maximize fungicide efficacy
    - *adjust the threshold down to 20% for susceptible varieties
  - -If not using prediction tools, focus your application at R3
  - -Application technology such as drop nozzles or drones can help improve efficacy and/or efficiency to get the application timing right!
- Other things to consider
  - -If planting in narrow row-spacing, reduce the seeding rate (100K)!
  - -Push for resistant varieties
  - -Conservation tillage can help reduce white mold
  - -Roller-crimping rye or using other cover crops can reduce white mold

The spatial coverage of our database is extensive and coincide with the region where most of corn and soybean are grown across the US





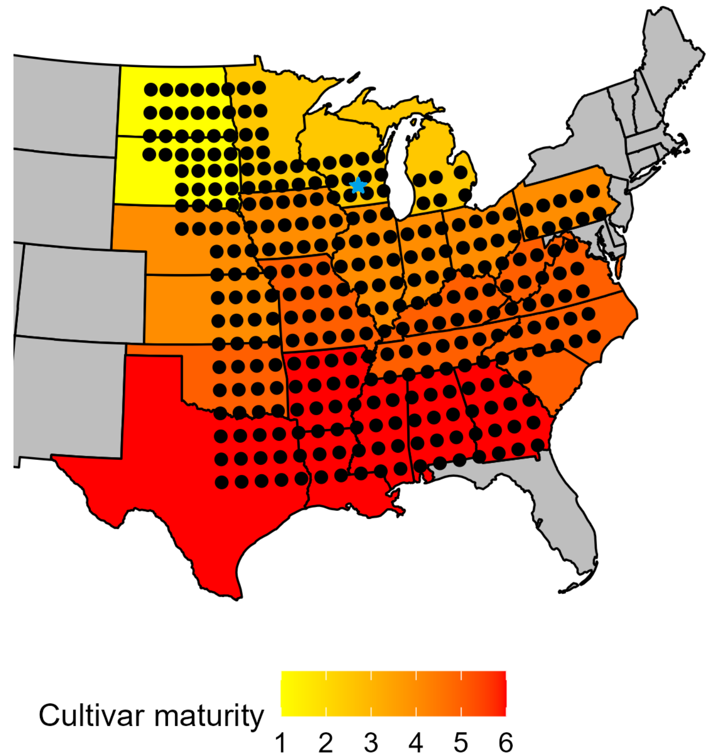
Goal

There are no studies examining how **crop planting order** within the same growing season can affect yield of both crops and gross farm revenue under variable background management and commodity selling prices.

Our goal was to evaluate the effect of these factors on gross farm revenue.

Crop planting order simulation

- Yield trends due to multiple planting dates in the same environment (soil type × weather conditions) were simulated for both crops for 310 locations across 26 states.
- In each location, two maturities were used for corn (105 and 115).
- For soybean, the average maturity in each state is shown with different color (yellow to red colors for early to late maturity, respectively).
- The blue star in Wisconsin shows the location of a randomly chosen field we present site-specific results.



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Some assumptions

Management decisions for typical and low-input corn and soybean cropping systems.

Management	Typical Corn	Low-input Corn	Typical Soybean	Low-input Soybean
Seeding rate (seeds/ac)	33,000	26,000	140,000	90,000
Nitrogen rate (lb/ac)	160	40	0	0

Partial economic analysis assumptions:

- Corn and soybean price were set to 5.1 and 12.2 $/bu, respectively.
- Soybean seed cost was set to $65/140,000 seeds.
- Corn seed cost was set to $300/80,000 seeds and nitrogen cost was set to 1 $/lb.
- We assumed 5000 ac of farmland, 2500 ac for each crop and planting capacity of 250 ac/day for both crops.

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Yield trends

Five-year mean corn (left y-axis) and soybean (right y-axis) yield in the field in Wisconsin for:

Revenue trends

Ratio of gross farm revenue (corn + soybean acres) in the field in Wisconsin when planting corn acres first and then soybean over planting soybean acres first and then corn for:

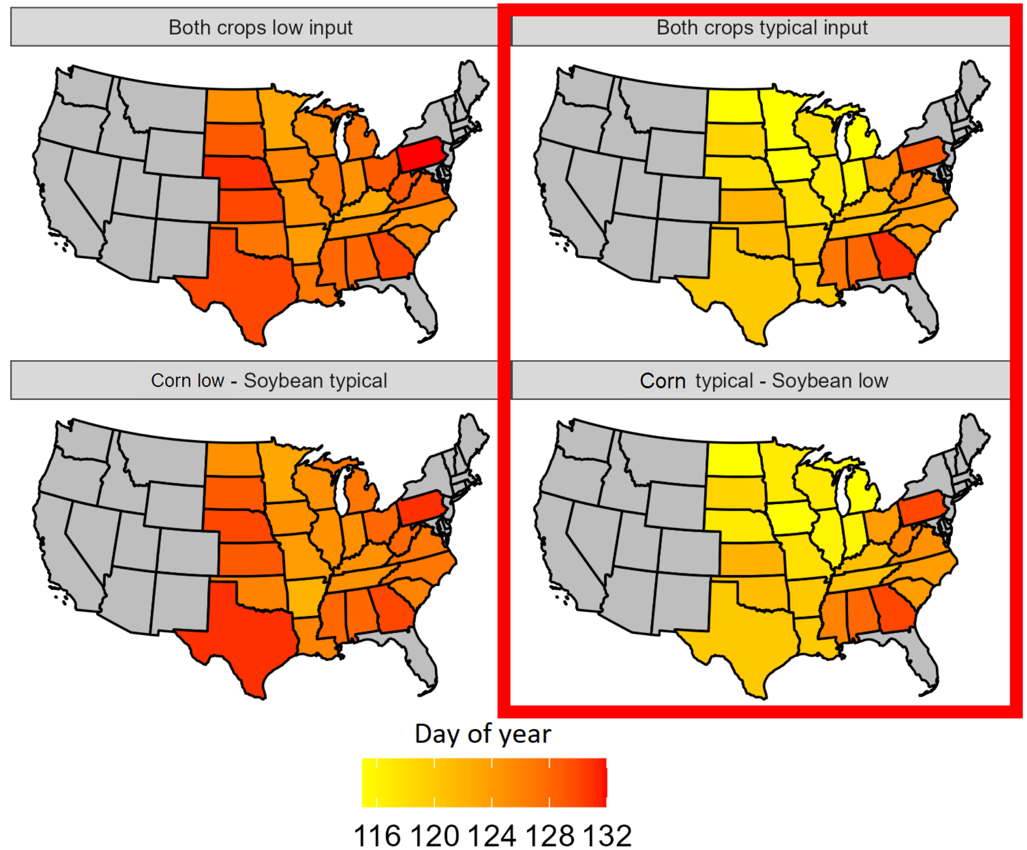
Across the US

Day of year that corn planting should be prioritized over soybean planting for maximum gross farm revenue (corn + soybean acres) between 110 to 145 day of year.

-When corn cropping systems were typical, corn planting should be prioritized early in the growing season in almost every state.

-Corn revenue is more sensitive to management decisions than soybean revenue.

-This shows that planting order decisions should first incorporate management optimization.



Crop planting order decision support tool

Field name	Crop	Acres	Production cost $/ac
Arl-North	corn	500	990
Arl-South	soybean	450	820
Arl-East	corn	280	1060
Arl-West	soybean	600	810

Assumptions

Planting capacity in ac/d =100

Corn price=$5/bu

Soybean price=$13/bu

Target date that planting will start =~~April 30~~

New target planting date =**May 10**

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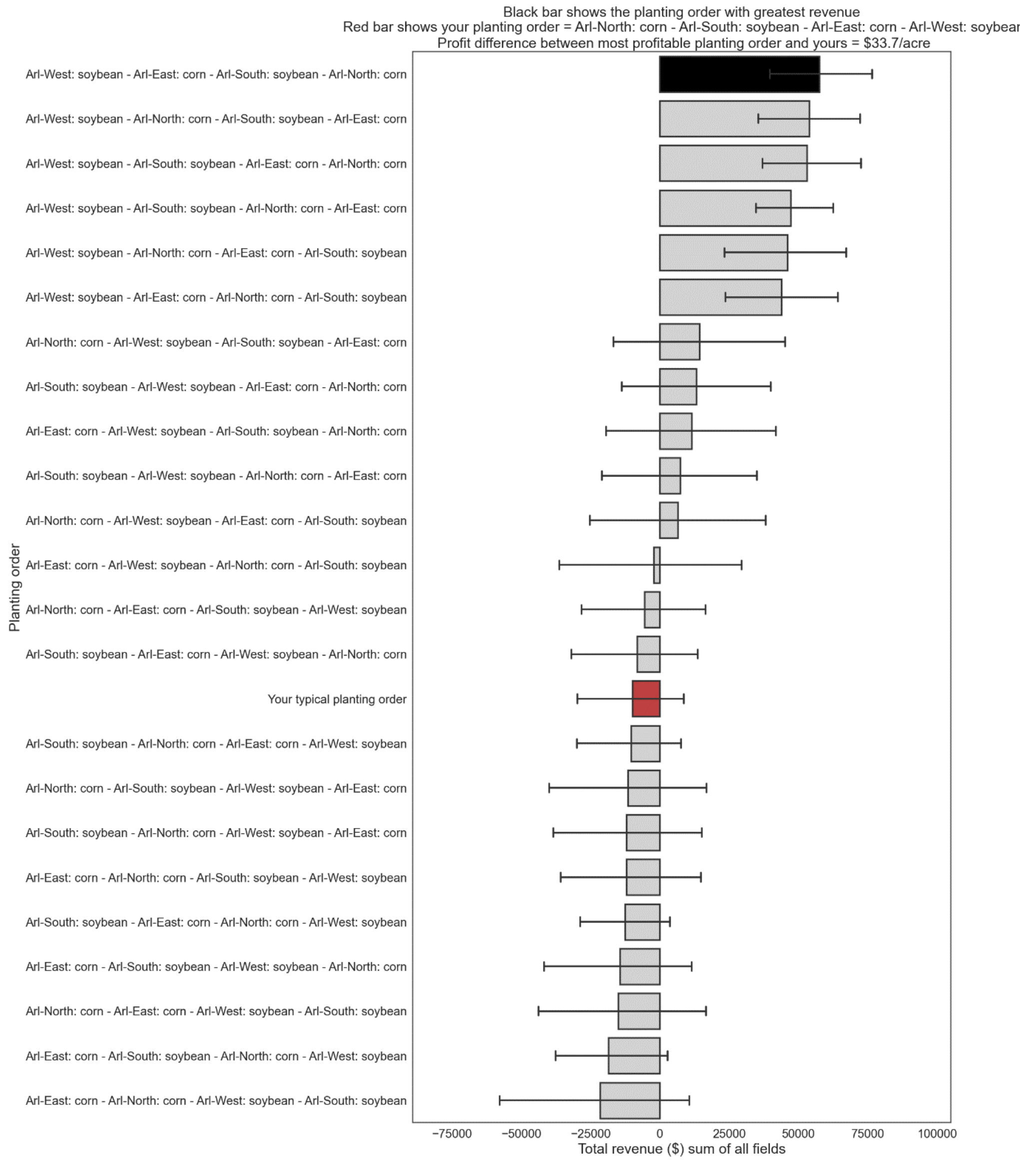

Advancing Agricultural Research Using Machine Learning Algorithms

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Agroptimizer

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Introduction

- Increasing food demand will challenge agricultural sector globally during the following decades.

- A sustainable part of the solution to this challenge is the increase of crop yields
  -without massive cropland area expansion.

- This can be achieved through agricultural research by identifying and adopting best management practices in each existing farm.

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Introduction *cont.*

- **Replicated field trials** is a common research approach used to estimate the effect of management practices on crop yield.
- Most commonly, the effectiveness of **up to three** management factors and their interactions are evaluated in a single location due to practical constraints (e.g., cost, logistics).
- By holding the background management constant, causal relationships are identified, and the effectiveness of the examined management is assessed.

Introduction *cont.*

- Results from the trials are difficult to extrapolate to all possible fields because they are dependent on specific soil types, weather conditions, and background management combinations.

- Seed genetics (G) and multiple management decisions (M), interact with environment (E) (soil and in-season weather conditions), and the infinite combinations of G × E × M determine crop yield.

- It is **assumed** that background management practices are optimal or at least relevant to what most farmers use in the region, which in fact may **not be realistic for many farmers**.

Introduction *cont.*

- Multi-year-site performance trials, that account for large environmental and background management variability, usually estimate an **average effect across fields** and background cropping systems.
  - Inevitably, the measured yield response may not apply to all farms in the examined region.

- Analysis of producer survey data, which can capture yield trends attributable to management choice across large regions, but it is **difficult to evaluate complex high-order G × E × M interactions**.

- Economic analysis is **rarely** performed.

Important questions

Farmers may ask:

- Optimize each management practice separately?
- What about 2-way or 3-way interactions between practices?
- Is it possible to optimize my entire cropping system for maximum yield (e.g., 8-way interaction)?
- My soil type and background management vary from what was used in the field trials…
  - **Should I expect the same yield response in my farm**?
  - **Is the cropping system for maximum yield the most profitable?**
  - **Input costs and prices change, should I adjust my cropping system to increase my profit?**

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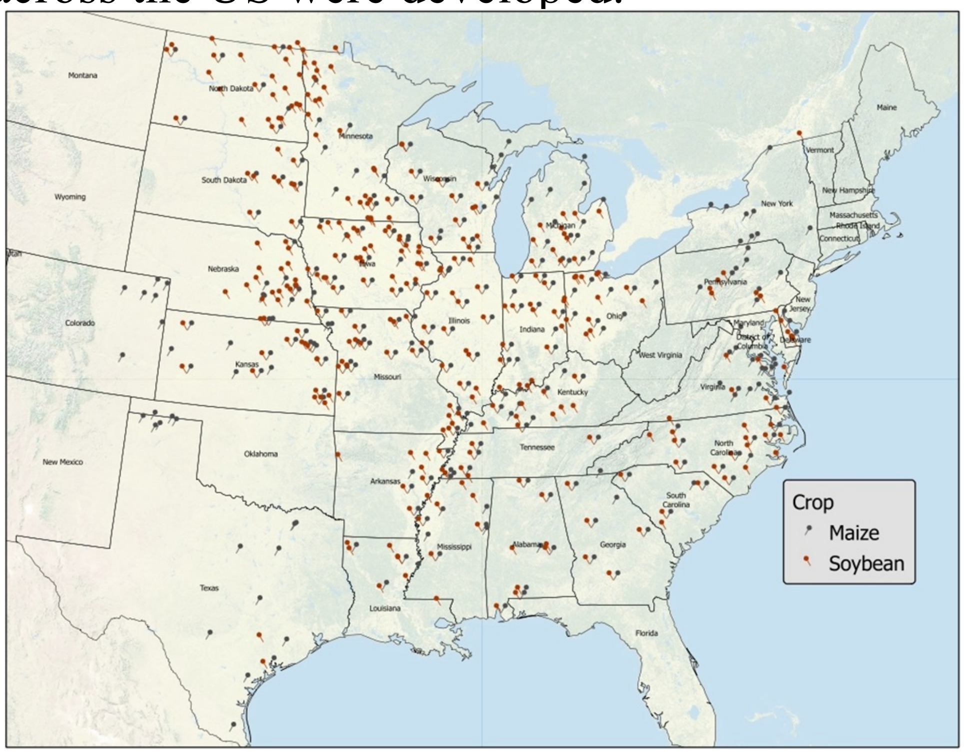
Objective

- Develop a method for rapid and accurate environment-specific identification of the cropping systems (complex interactions) with the greatest yield potential.

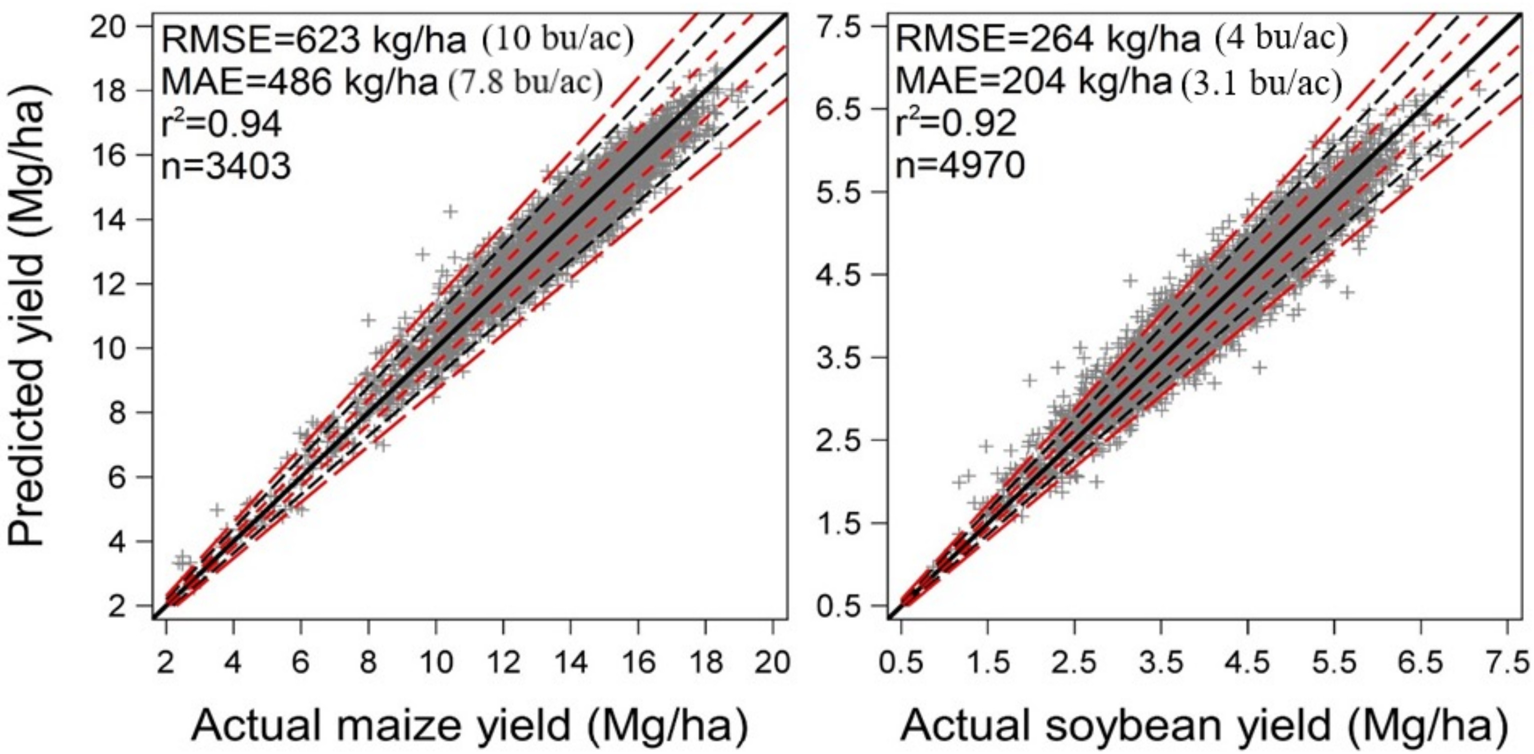
- By using data science and machine learning algorithms, we developed a method to evaluate thousands of potential cropping systems and identify those with the greatest **yield and profit** potential in each farm across the US.

Methods

- Databases including yield, management, and weather data for: **corn (n=17,000 G × E × M-specific yields)** and **soybean (n=25,000 G × E × M-specific yields)** across the US were developed.



Validation



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A hypothetical scenario for soybean in Arlington WI

Variable	Levels used
Planting date	May 1st, June 1st
Tillage practice	Conventional, No-till
Seeding rate (seeds/ac)	140,000, 160,000
Row spacing (inches)	15, 30
Foliar fungicide use	yes, no
Cultivar maturity group	1, 2
Previous crop	corn, soybean

128 management combinations × 5 years = 640 G × E × M-specific yields

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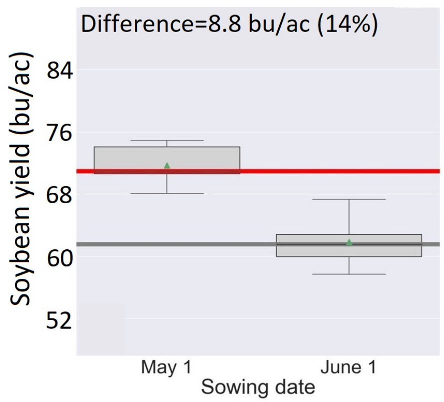
Results for soybean *cont.*

Effect of planting date



Soybean yield difference due to planting date (May 1st vs June 1st) with early planting

for a single identical background cropping system

when averaged across 5 years x 128 cropping systems=640 year-specific yields

Results for soybean *cont.*

Management practices in the highest and lowest yielding cropping systems with **early planting date (May 1st)**

Management	Highest yielding system	Lowest yielding system
Cultivar maturity	2	1
Seeding rate (seeds/ac)	160,000	140,000
Row spacing (inches)	15	30
Foliar Fungicide use	yes	no
Tillage practice	No-till	No-till
Previous crop	Corn	Soybean

A hypothetical scenario for corn in Lincoln NE

Variable	Levels used
Planting date	April 30th, May 10th, May 20th
Seeding rate (seeds/ac)	28,000, 33,000, 38,000
Nitrogen fertilizer (lb/ac)	0, 75, 150, 225
Row spacing (inch)	15, 30
Previous crop	corn, soybean
Maturity	100, 105, 110

432 management combinations × 5 yrs = 2160 G × E × M-specific yields

For each N rate: 108 background management combinations × 5 yrs = 540 G × E × M-specific yields

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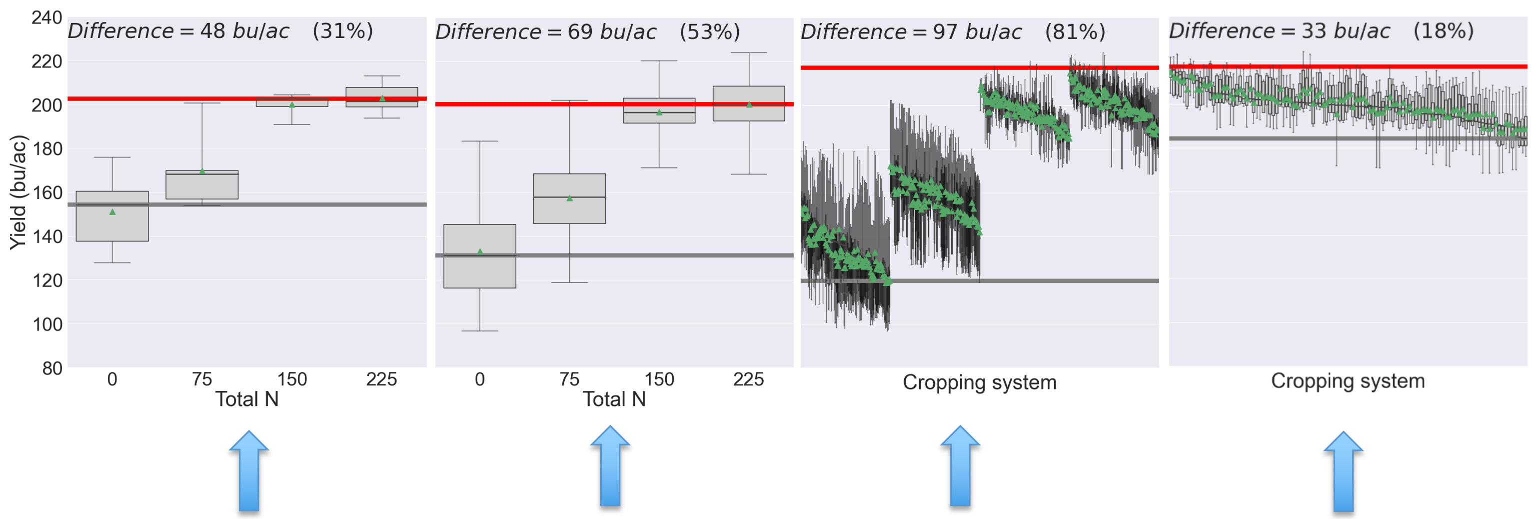
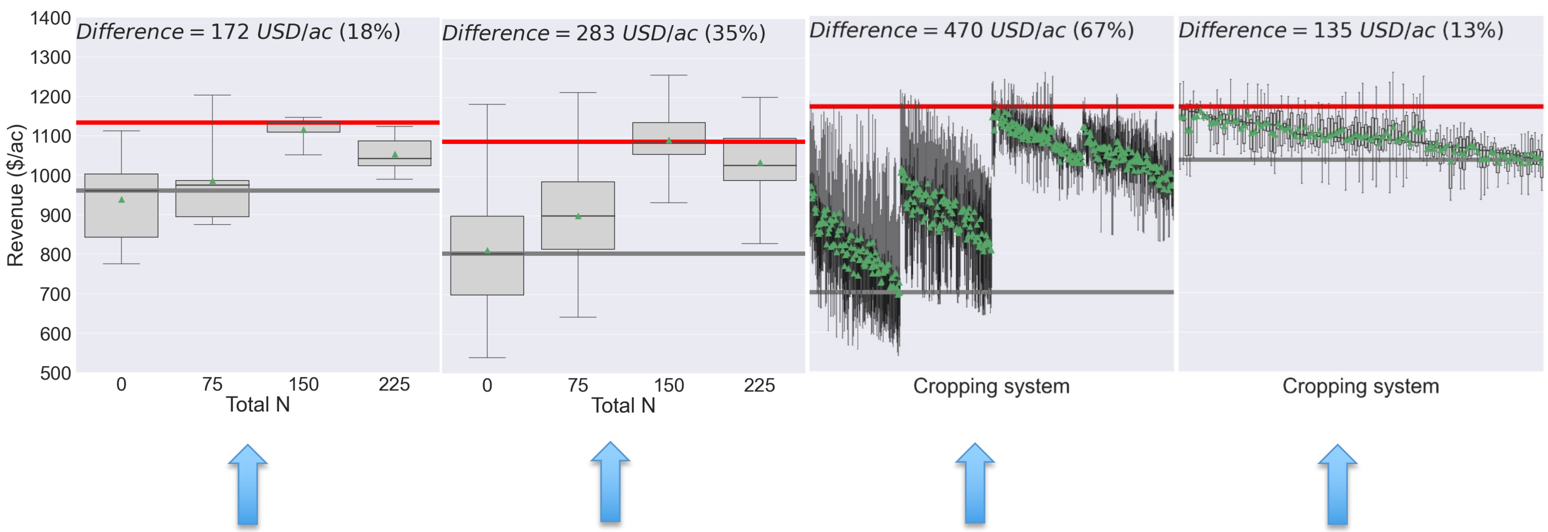
Effect of Nitrogen rate on corn yield



Corn yield as affected by N rate [illegible]
(average of 5 years × 108 cropping systems)

Effect of Nitrogen rate on corn revenue



Corn revenue as affected by N rate
(average of 5 years × 108 cropping systems)

Results for corn *cont.*

Corn cropping systems for **high yield** and **high revenue**

Management	System for high yield	System for high revenue
Planting date	April 30th	April 30th
Seeding rate (seeds/ac)	33,000	28,000
Nitrogen fertilizer (lb/ac)	225	150
Row spacing (inch)	15	15
Previous crop	Soybean	Soybean
Maturity	110	110

Conclusions

- The presented approach can generate hypothetical experimental data that can be used to rapidly examine G × E × M interaction for corn and soybean across the US.

- **Researchers** can compare expected yield across thousands of hypothetical cropping systems and use the results as a guide to design more efficient future field-based experiments.

- **Farmers** can use the algorithms to gain insights about optimum management interactions in their location-specific environment.

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BOOTS ON THE GROUND ver. 2

AI-DRIVEN TOOLS FOR MAXIMIZING SOYBEAN YIELD AND PROFITABILITY

AGRONOMIC MANAGEMENT COMPARISON

- **Here's our goal!**
  Participating farmers will be able to evaluate their present agronomic system (i.e. planting date, seeding rate, row spacing, use of foliar pesticides, and nitrogen rate) against *Agroptimizer* recommendations for their specific field location, soil type, tillage practice, seed, nitrogen, and pesticide costs and projected soybean selling price.

- **Our ask!**
  Share a soybean field on your farm with us to compare your regular management plan with Agroptimizer recommendations using in-season field conditions.

- **How do you benefit?**
  Help us validate the outputs and provide valuable data to help adjust and update our algorithm. The tool will provide insights for best management practices in your fields that can help increase yield and profit.

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NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Recruiting for On-Farm Research in 2025 (Part1)

Do you grow soybeans?

AGRONOMIC MANAGEMENT COMPARISON

Can you help us test our data-based Agroptimizer recommendations in your field?

We need your help!

Participating states:

WI, PA, OH, MI, IA, ND, IN, NE, IL, MO

Identify a field	Plan and initiate treatments	Season long monitoring	Data analysis
Share a field to do the test 5 acres or more Mostly uniform soils with even drainage and slope Crop, tillage and fertilizer application history available Fields with previous yield history No large historically wet areas, previous building sites, roads, internal fence lines	Using Agroptimizer, plan comparison treatments Plant trial according to planned treatments	We will add: Bi-weekly scouting by UW BeanTeam Soil sampling Disease monitoring Growth staging and weather monitoring Soil data Weather data Satellite image data	Share management information and yield data to test profitable management recommendations from your field We will protect the confidentiality of your field data $500 honorarium for your efforts

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NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

To participate, contact:
John Gaska
jmgaska@wisc.edu
608-220-2693

BOOTS ON THE GROUND ver. 2

AI-DRIVEN TOOLS FOR MAXIMIZING SOYBEAN YIELD AND PROFITABILITY

FIELD SCOUTING ALERT SYSTEM

- **Here's our goal!**
  We developed a new tool that uses Sentinel-2 satellite images to automatically calculate the Normalized Difference Vegetation Index (NDVI-a plant health index) NDVI will be automatically generated every 5-10 days when new satellite images are available. These grids can be used to guide precision scouting efforts throughout the growing season.

- **Our ask!**
  - We would like to scout a field on your farm this season
  - We'll do all the work! Just grow your soybean crop normally
  - We will come in and scout your field every 2-3 weeks throughout the season
  - We'll be looking for insects, weeds, diseases, growth stages, and abiotic stressors
  - We'd ask for your yield monitor data at the end of the year

- **How do you benefit?**
  By providing your field data, you can help us test our satellite imagery tool to help make field scouting more efficient. The more data we collect, the more accurate the tool will be.

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NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Recruiting for On-Farm Research in 2025 (part 2)

Do you grow soybeans?

FIELD SCOUTING ALERT SYSTEM

We need your help!

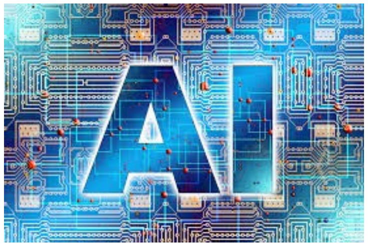
Help us validate our new satellite imagery enhanced field scouting system

What we need from you

- We would like to scout a field on your farm this season
- We'll do all the work! Just grow your soybean crop normally
- We will come in and scout your field every 2-3 weeks throughout the season
- We'll be looking for insects, weeds, diseases, growth stages, and abiotic stressors
- We'd ask for your yield monitor data at the end of the year

What we will do for you

- Help us test our satellite imagery tool to help make field scouting more efficient
- The more data we collect, the more accurate the tool will be.
- We will protect the confidentiality of your field data
- $500 honorarium for your efforts



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To participate, contact:
John Gaska
john.gaska@wisc.edu
608-220-2693

Agroptimizer: A cloud-based crop management tool

www.agroptimizer.com

SCAN ME

Optimize Your Farm Management

Evaluate thousands of management combinations to understand how different practices influence **yield** and **profit**.

1.Pinpoint Your Field

Drop a pin on your field and provide key details such as soil type, tillage practices, etc.

2.Analyze Multiple Variables

Compare yield and profit outcomes across combinations of:

1. Planting dates
2. Seeding rates
3. Row spacing
4. Foliar fungicide/insecticide applications
5. Nitrogen fertilizer levels

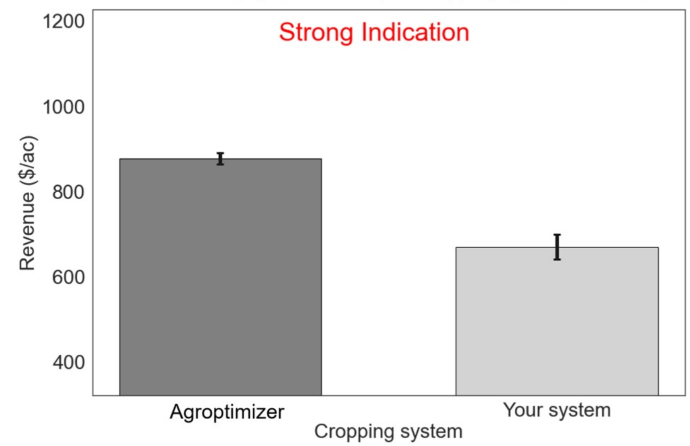
3.Gain Instant Insights

Within minutes, discover the most profitable cropping system tailored to your field's conditions.

Management	Your practice	Agroptimizer
Planting date=	May 20	April 30
Trait, seed treatment and maturity=	GMO-FI-1.5	GMO-FI-1.5
Seeding rate (x1000 seeds/ac)=	140	170
Row spacing (inches)=	30	15
Foliar Application=	no	no
Nitrogen rate (actual lb/ac)=	0	0

Yield difference (Agroptimizer vs your cropping system)=17.7 bu/ac

Profit difference (Agroptimizer vs your cropping system)=207.5 $/ac



BOOTS ON THE GROUND ver. 2

AI-DRIVEN TOOLS FOR MAXIMIZING SOYBEAN YIELD AND PROFITABILITY

RESOURCES

Local

- Shawn Conley
  608-800-7056
- John Gaska
  608-220-2693
- Your local UWEX Regional Crops Educator

Agroptimizer.com

Regional

WI > Shawn Conley: spconley@wisc.edu
PA > Paul Esker: pde6@psu.edu
OH > Laura Lindsey: lindsey.233@osu.edu
MI > Maninderpal Singh: msingh@msu.edu
IA > Joe McClure: joem@iasoybeans.com
NE > Nicolas La Menza: nicolas.cafaro@unl.edu
ND > Lindsay Malone: lindsay.malone@ndsu.edu
MO > Blake Barlow: bbarlow@mosoy.org
IN > Christian Krupke: ckrupke@purdue.edu
IL > Nicholas Seitler: nseiter@illinois.edu

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