Planting soybean green: agronomic and weed management benefits and challenges

<u>Jose Nunes*</u>, Arneson N, Johnson B, Young B, Ikley J, Wallace J, Gage K, Jha P, Lancaster S, Legleiter T, Kumar K, and Werle R.

*Graduate student, University of Wisconsin-Madison

Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN–MADISON

Department of Agronomy,
University of Wisconsin-Madison

What is planting green?

Soybean

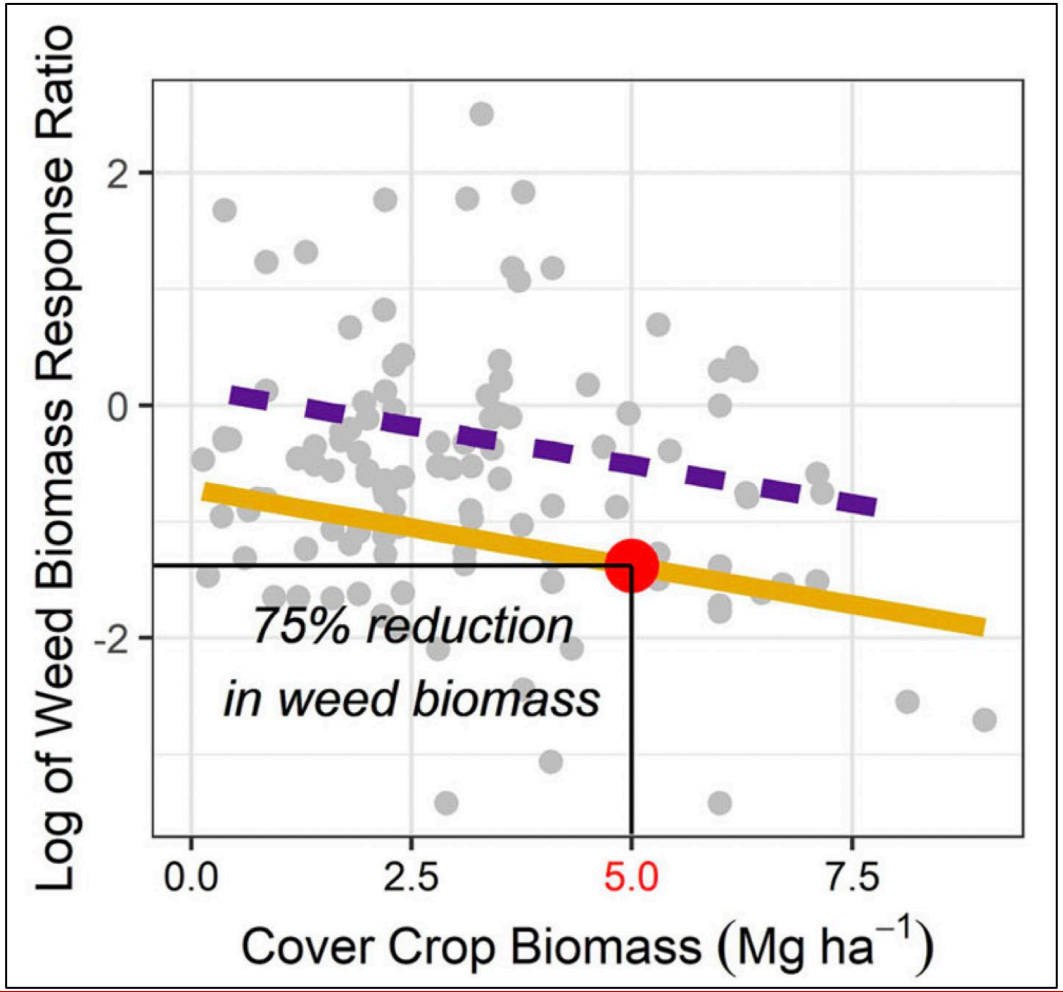
Cereal rye

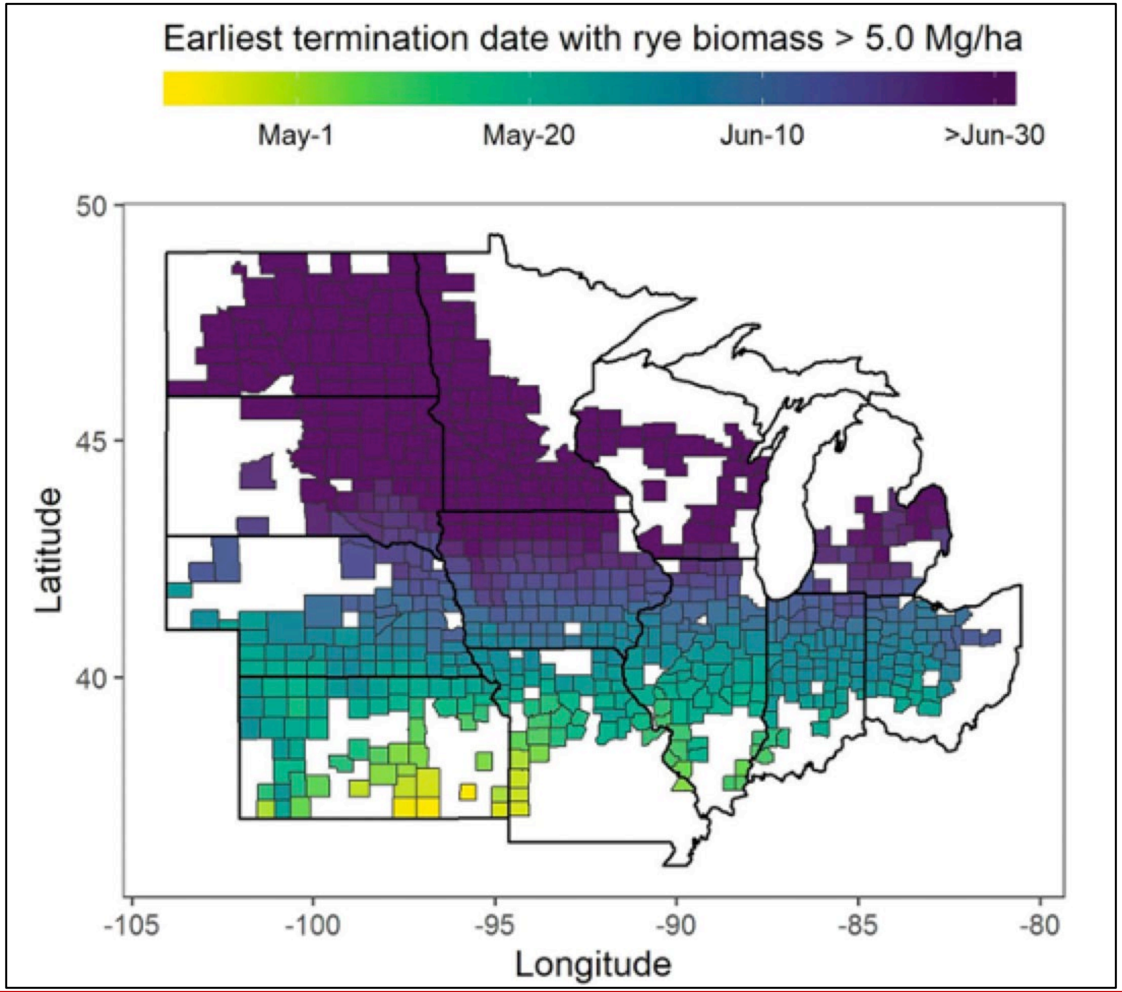
The practice of planting a **cash crop** into a **living cover crop** to maximize **ecosystem services** provided by cover crops (Reed & Karsten, 2022).

Waterhemp suppression

Introduction |

Meta-analysis by Nichols et al. (2020) on cover crops and weed suppression





Introduction |

Standard termination

Planting green

Can the planting green system optimize cereal rye biomass accumulation (target 5 Mg ha^{-1}) without postponing soybean planting time?

5 Mg ha^{-1} = 4,460 Lbs ac^{-1}

Year 1: Corn	Cereal rye	Year 2: Soybean
Apr – Oct/Nov	Oct/Nov – Apr/May	Apr/May - Oct

Introduction |

PRE herbicides can improve pigweed control when associated with cover crops

Efficacy of residual herbicides influenced by cover-crop residue for control of *Amaranthus palmeri* and *A. tuberculatus* in soybean

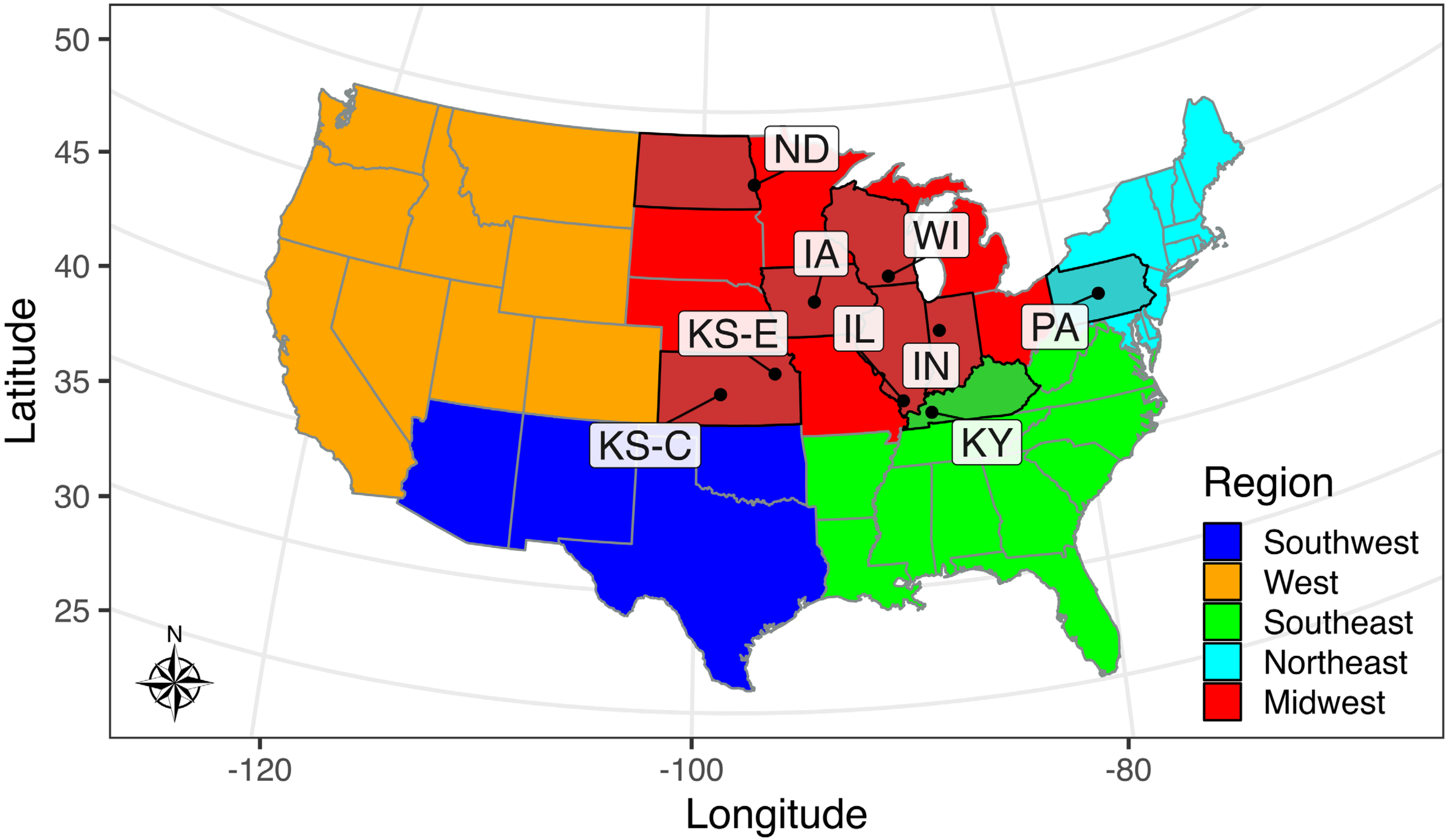
Clay M. Perkins[1], Karla L. Gage[2], Jason K. Norsworthy[3], Bryan G. Young[4], Kevin W. Bradley[5], Mandy D. Bish[6], Aaron Hager[7] and Lawrence E. Steckel[8]

Introduction |

Objective: Evaluate the impacts of **planting soybean green** and its interactions with PRE-emergence herbicides on **waterhemp management** and **soybean yield.**

Hypothesis: Planting green can lead to **higher cereal rye biomass** accumulation and **better waterhemp suppression** without a negative impact on soybean yield.

Materials & Methods | Study Locations 2021

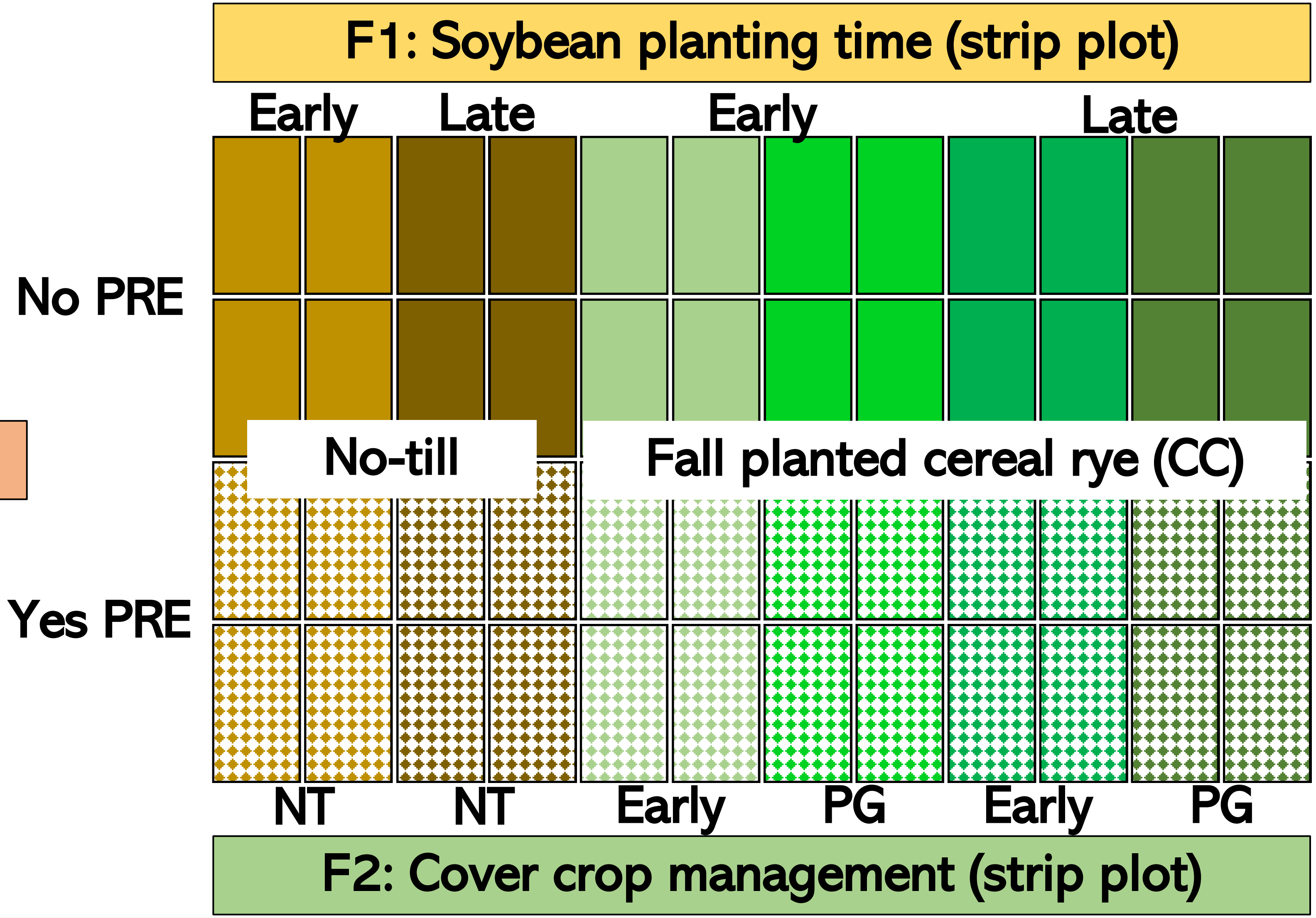


IA: Iowa S U - Dr. Jha
IL: Southern Illinois U - Dr. Gage
IN: Purdue U - Drs. Young & Johnson
KS-C: Kansas S U (Central) - Dr. Kumar
KS-E: Kansas S U (East) - Dr. Lancaster
ND: North Dakota S U - Dr. Ikley
PA: Penn S U - Dr. Wallace
KY: U of Kentucky - Dr. Legleiter
WI: U of Wisconsin - Dr. Werle

Materials & Methods | Study Design

- 2x3x2 Factorial
- Strip-plot (RCBD)
- 4 blocks
- 3x9.1 m plots

F3: Use of PRE (split-plot)



PG: Planting green

Materials & Methods | Study Establishment

Site	Cereal rye planting date (Planted at 67 kg ha^{-1})	Soybean planting date: Early soybean	Soybean planting date: Late soybean	Soybean variety (76-cm row spacing)
ND	September 16, 2020	May 19, 2021	June 1, 2021	Pioneer 06T56E
KS-C	September 17, 2020[1]	May 7, 2021	May 27, 2021	P30T99E
KS-E	September 24, 2020	May 4, 2021	May 25, 2021	P39T61SE
WI	September 25, 2020	May 7, 2021	May 18, 2021	S20-E3
KY	October 1, 2020	April 24, 2021	May 25, 2021	P41T07E[2]
PA	October 1, 2020	May 3, 2021	May 18, 2021	IS234E3
IL	October 2, 2020	May 7, 2021	May 17, 2021	NKS39-E3
IN	October 12, 2020	May 16, 2021	June 1, 2021	Stine 32EA12
IA	November 6, 2020	May 14, 2021	May 21, 2021	NKS28-E3

[1]Only site to plant rye at 39 kg ha^{-1}
[2]Only site with 38-cm row spacing

Avg of 16 days

Materials & Methods | Herbicide Applications

- CO_2 backpack sprayer
- 140 L ha^{-1} of spray solution
- AMS @ 1% v/v

Cereal rye termination

- glyphosate @ 1,262 g ae ha^{-1}

PRE - at planting

- flumioxazin @ 70.4 g ai ha^{-1}
- pyroxasulfone @ 89.3 g ai ha^{-1}
- glufosinate @ 655 g ai ha^{-1}

POST - 20% of waterhemp plants 10-cm height

- 2,4-D @ 1,064 g ae ha^{-1}
- glufosinate @ 655 g ai ha^{-1}
- clethodim @100 g ai ha^{-1}
- acetochlor @ 1,260 g ai ha^{-1}

Materials & Methods | Data Collection & Analysis

Cereal rye biomass at termination (Mg ha^{-1})

Aboveground biomass sampled in three 0.1 m^{-2} quadrats from each plot

Linear Mixed-Effect Model

Biomass ~ Cereal rye termination * Soybean planting * PRE + (1|Location/Block)

Response variable — Biomass

Fixed effects — Cereal rye termination * Soybean planting * PRE

Random effects — (1|Location/Block)

Estimated marginal means – LSD test (α: 0.05)

Materials & Methods | Data Collection & Analysis

Waterhemp density at POST application (plants m^{-2})
Counted emerged plants in two 1 m^{-2} quadrats from each plot

Linear Mixed-Effect Model

Waterhemp density ~ Cover crop management * Soybean planting * PRE + (1|Location/Block)

Response variable
Square-root transformation
Back transformed means reported

Fixed effects

Random effects

Estimated marginal means – LSD test (α: 0.05)

Materials & Methods | Data Collection & Analysis

Soybean yield (kg ha^{-1})
Harvested the two center rows of each plot

Linear Mixed-Effect Model

Soybean yield ~ Cover crop management * Soybean planting * PRE * Location + (1|Block)

Response variable | **Fixed effects** | **Random effect**

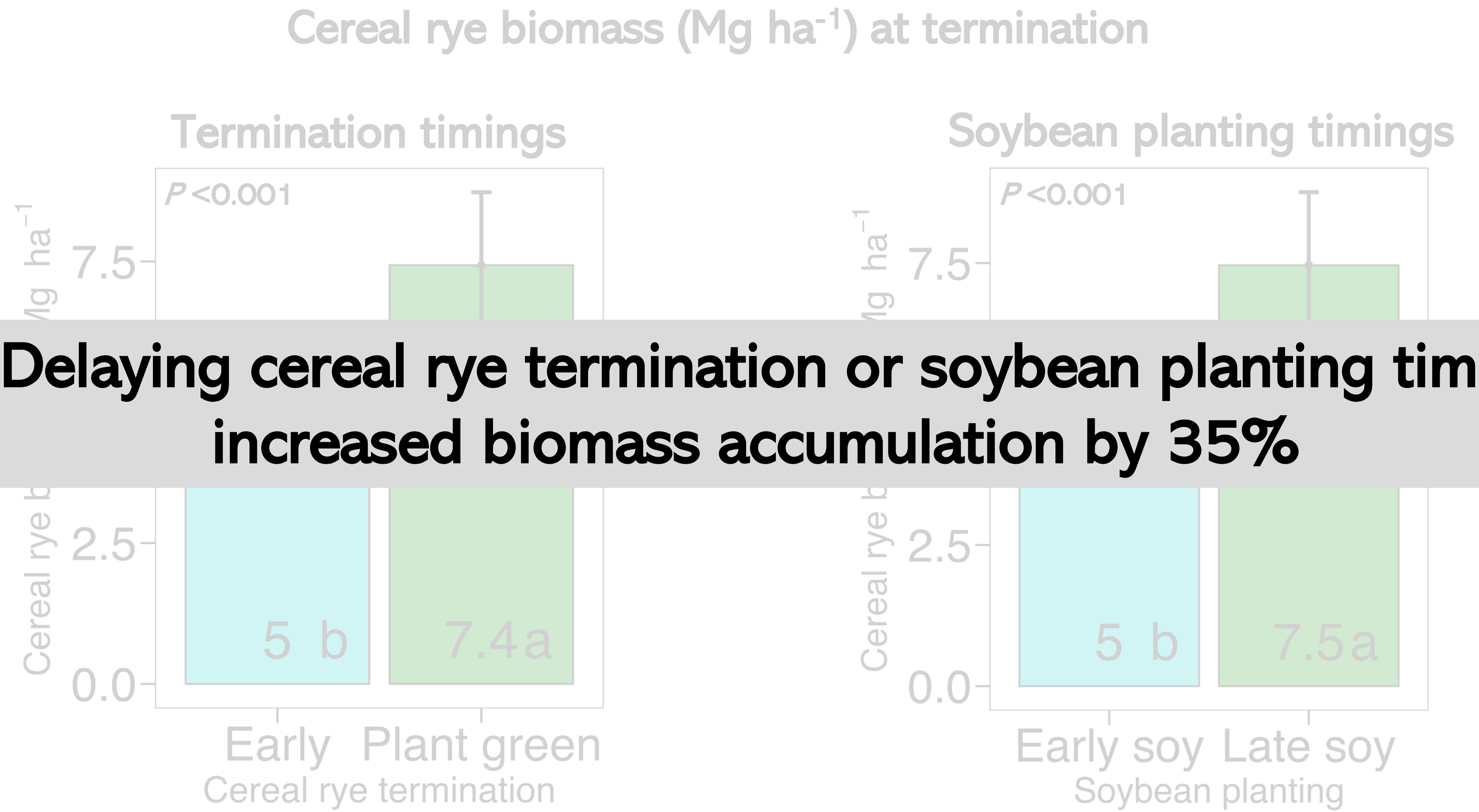
Estimated marginal means – LSD test (α: 0.05)

Materials & Methods | Data Collection & Analysis

- R software version 4.2.1 (R Core Team 2022)
- Data wrangling and visualization (***tidyverse*** package)
- Linear Mixed-Effect Models (***lme4*** package)
- Estimated marginal means (***emmeans*** package)
- Compact letter display (***multcomp*** package)

Results

Results | Cereal Rye Biomass



Delaying cereal rye termination or soybean planting time increased biomass accumulation by 35%

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Error bars indicate the standard error of means

Means followed by the same letter do not differ statistically among themselves by the LSD test (α: 0.05)

Results | Cereal Rye Biomass

Cereal rye is extremely responsive to heat accumulation in the spring

Agronomy Journal

ARTICLE

Crop Economics, Production, and Management

Does winter cereal rye seeding rate, termination time, and N rate impact no-till soybean?

Heidi K. Reed | Heather D. Karsten

Effects of fall-planted cereal cover-crop termination time on glyphosate-resistant horseweed (*Conyza canadensis*) suppression

John A. Schramski[1], Christy L. Sprague[2] and Karen A. Renner[2]

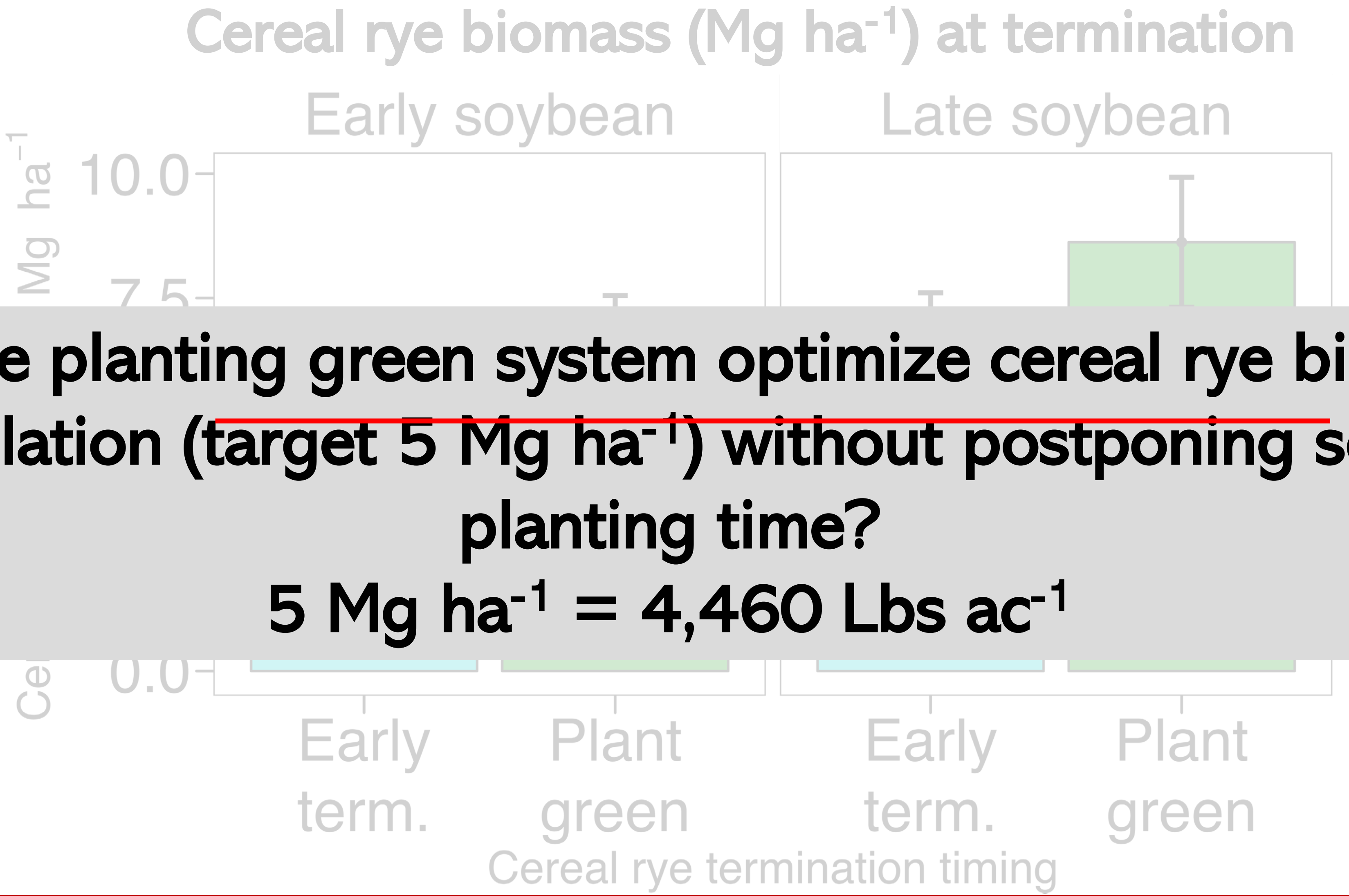
[1]Graduate Student, Department of Plant, Soil and Microbial Sciences, East Lansing, MI, USA and [2]Professor, Department of Plant, Soil and Microbial Sciences, East Lansing, MI, USA

Utilizing cover crops for weed suppression within buffer areas of 2,4-D-resistant soybean

Connor L. Hodgskiss[1], Bryan G. Young[2], Shalamar D. Armstrong[3] and William G. Johnson[2]

[1]Graduate Research Assistant, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, USA; [2]Professor, Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN, USA and [3]Professor, Department of Agronomy, Purdue University, West Lafayette, IN, USA

Results | Cereal Rye Biomass



Can the planting green system optimize cereal rye biomass accumulation (target 5 Mg ha^{-1}) without postponing soybean planting time?

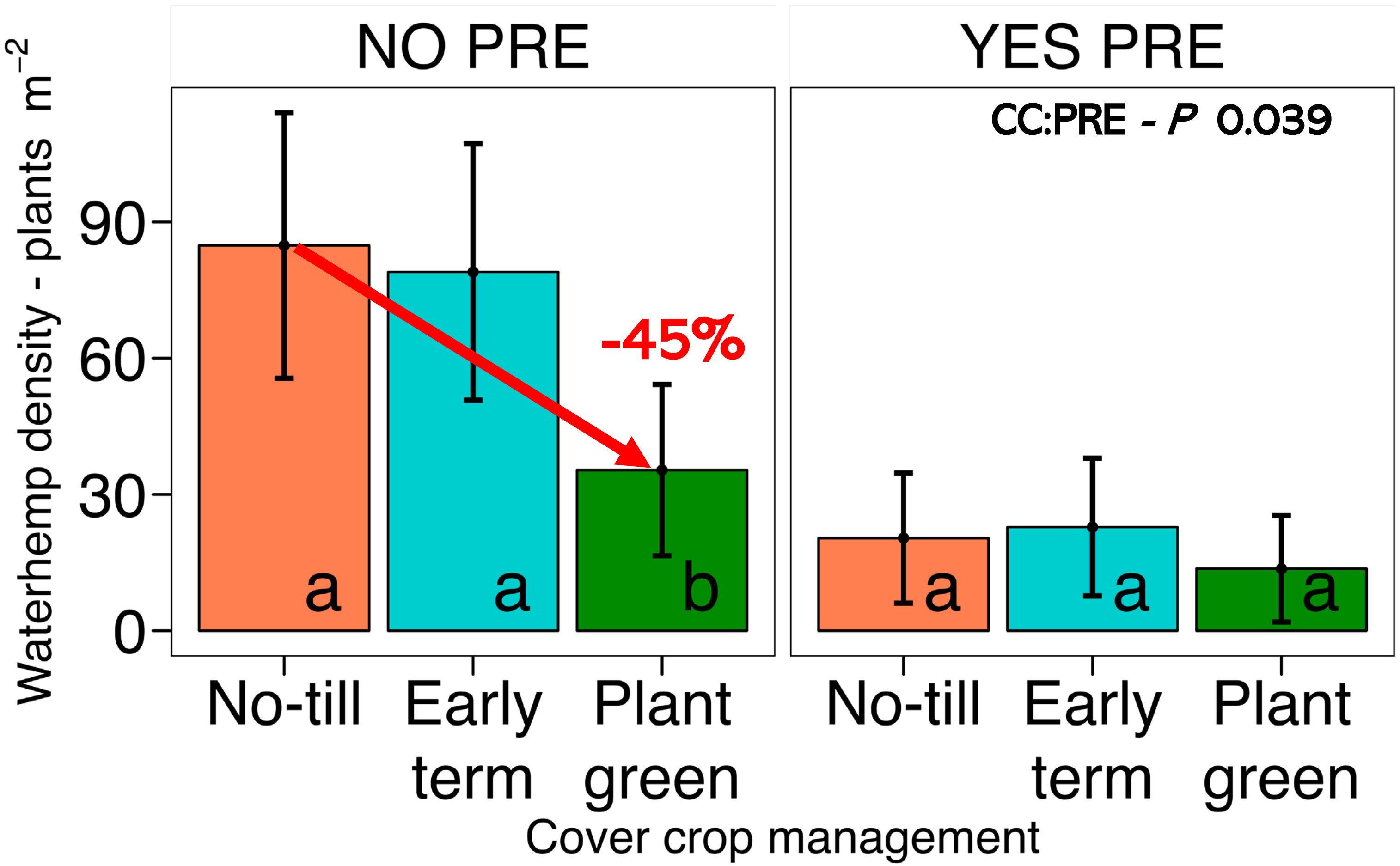
5 Mg ha^{-1} = 4,460 Lbs ac^{-1}

Error bars indicate the standard error of means

Means followed by the same letter do not differ statistically among themselves by the LSD test (α: 0.05)

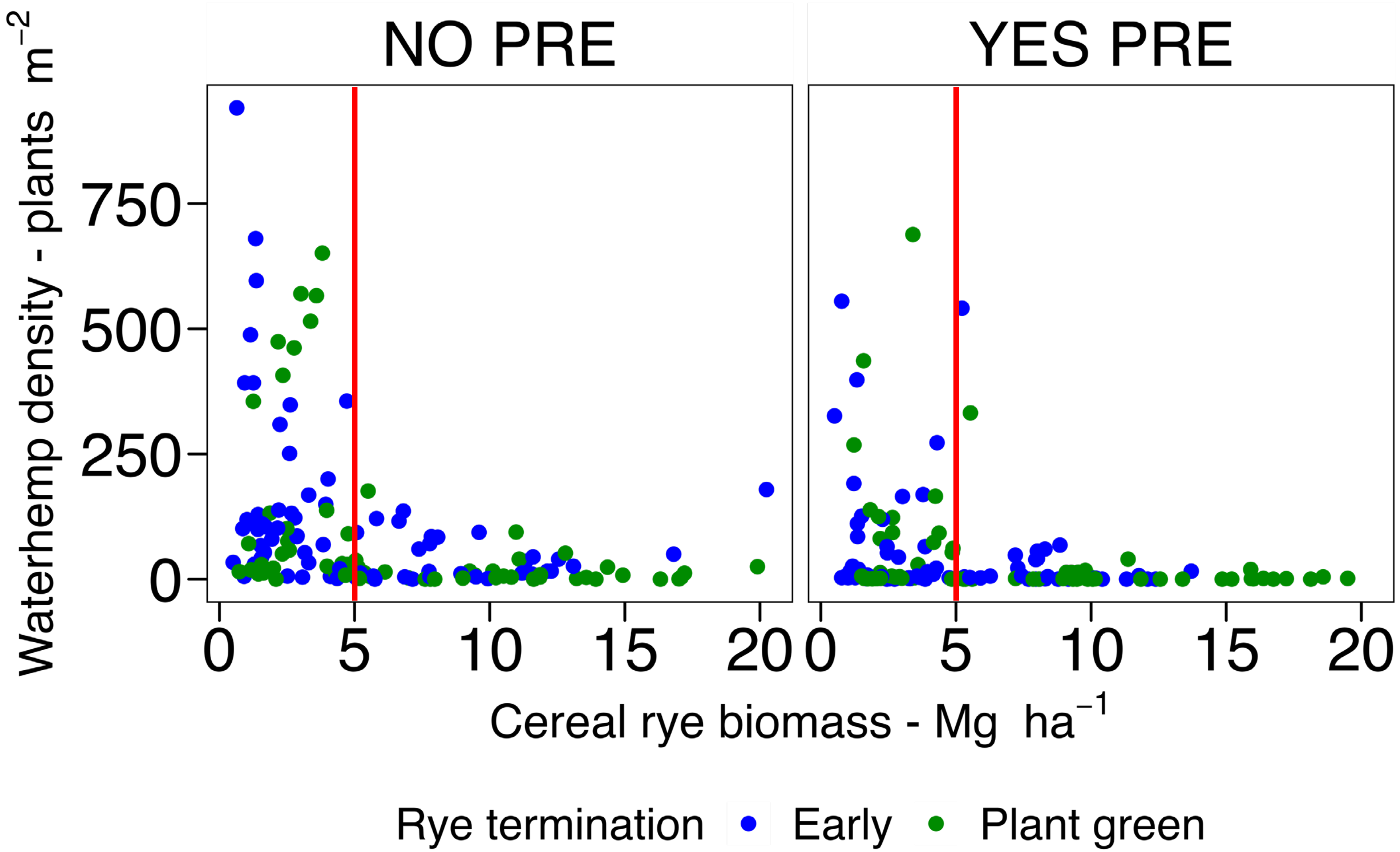
Results | Waterhemp Density

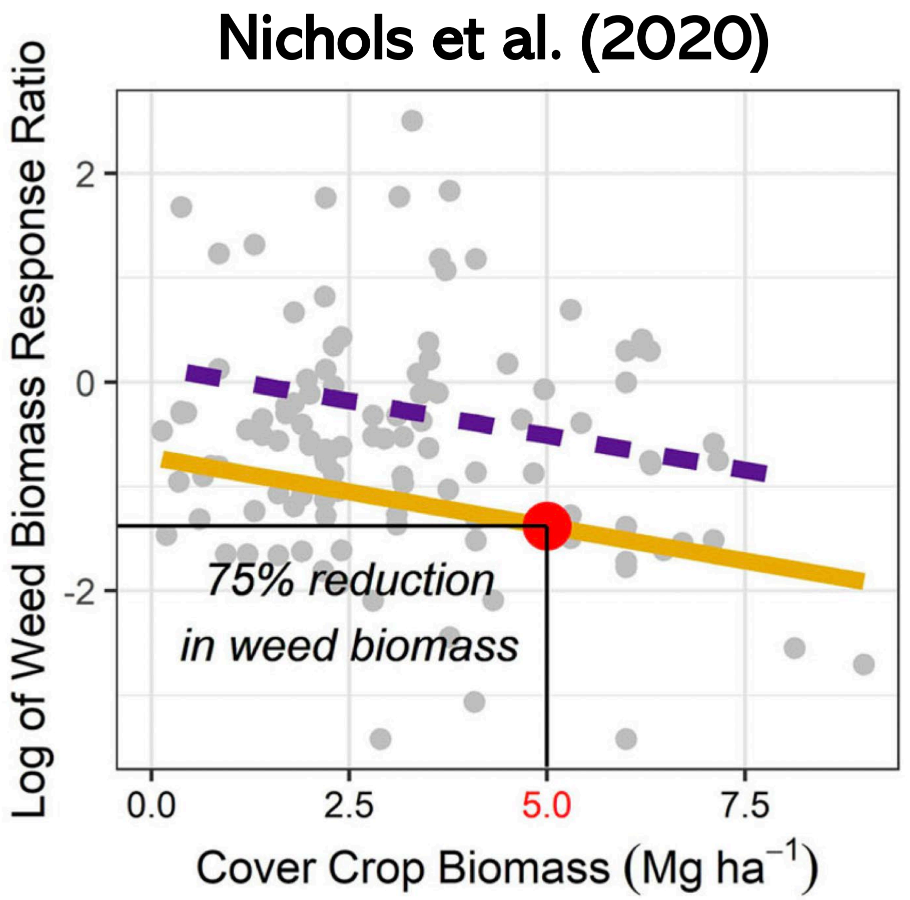
Waterhemp density (plants m^{-2}) at POST application



CC: Cover crop management effect. PRE: PRE-emergence herbicide effect
Error bars indicate the standard error of means
Means followed by the same letter do not differ statistically among themselves by the LSD test (α: 0.05)

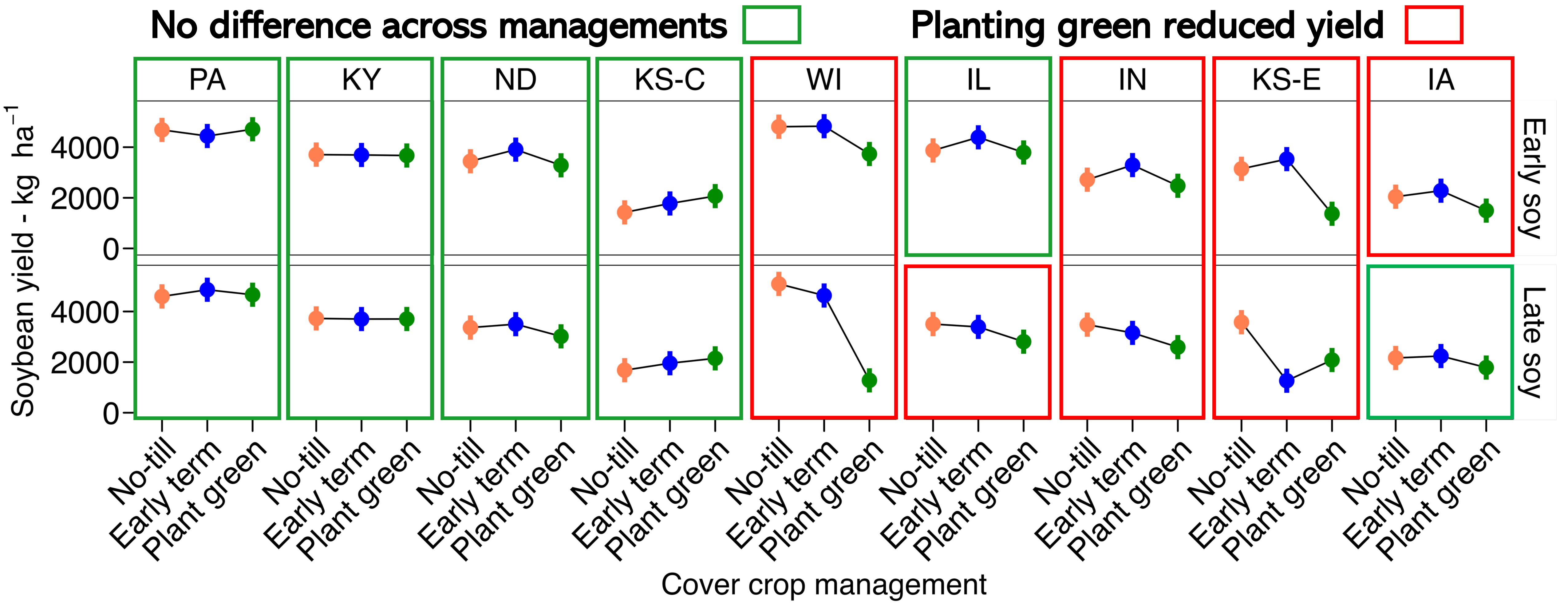
Results | Waterhemp Density



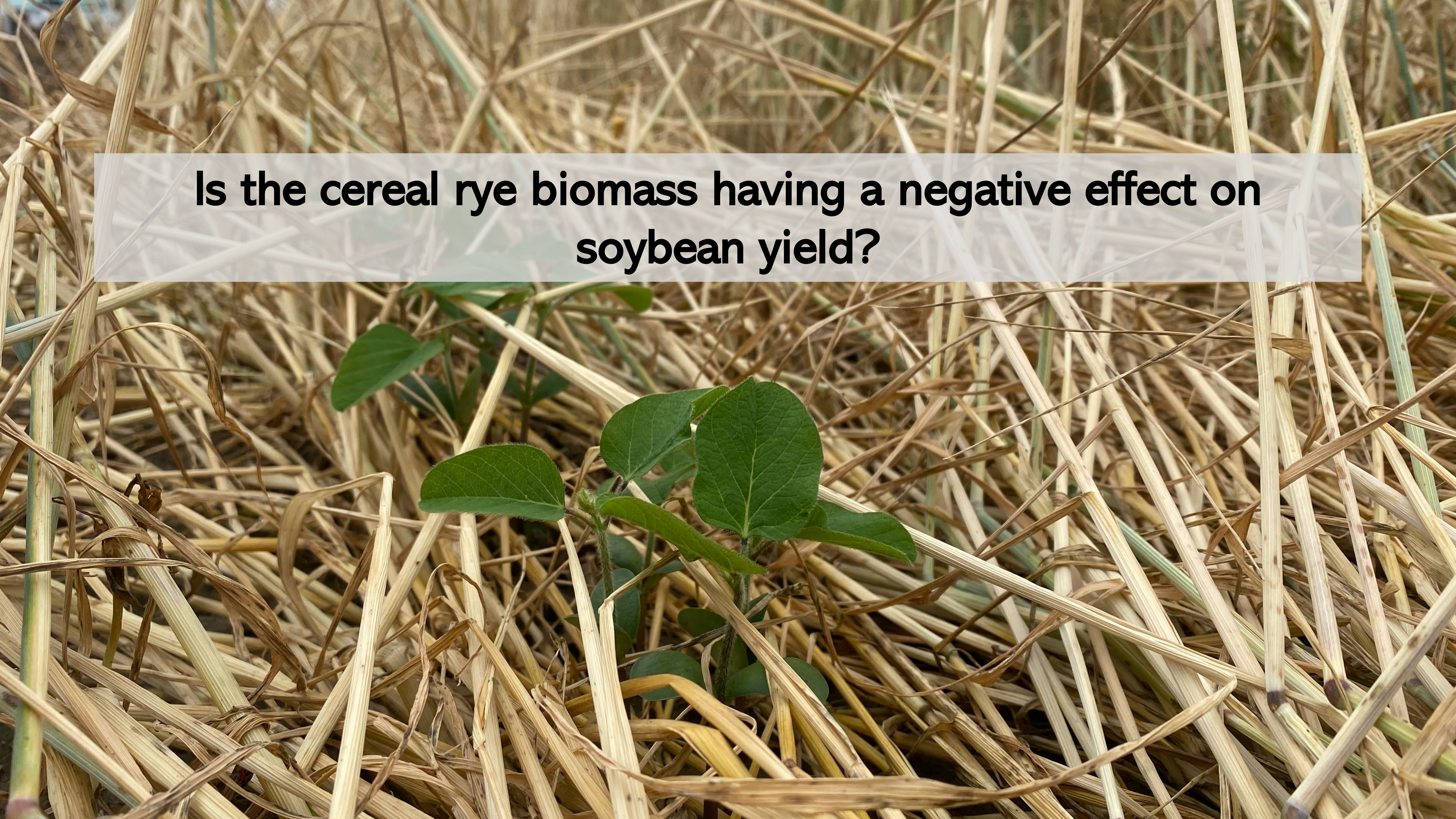


Results | Soybean Yield

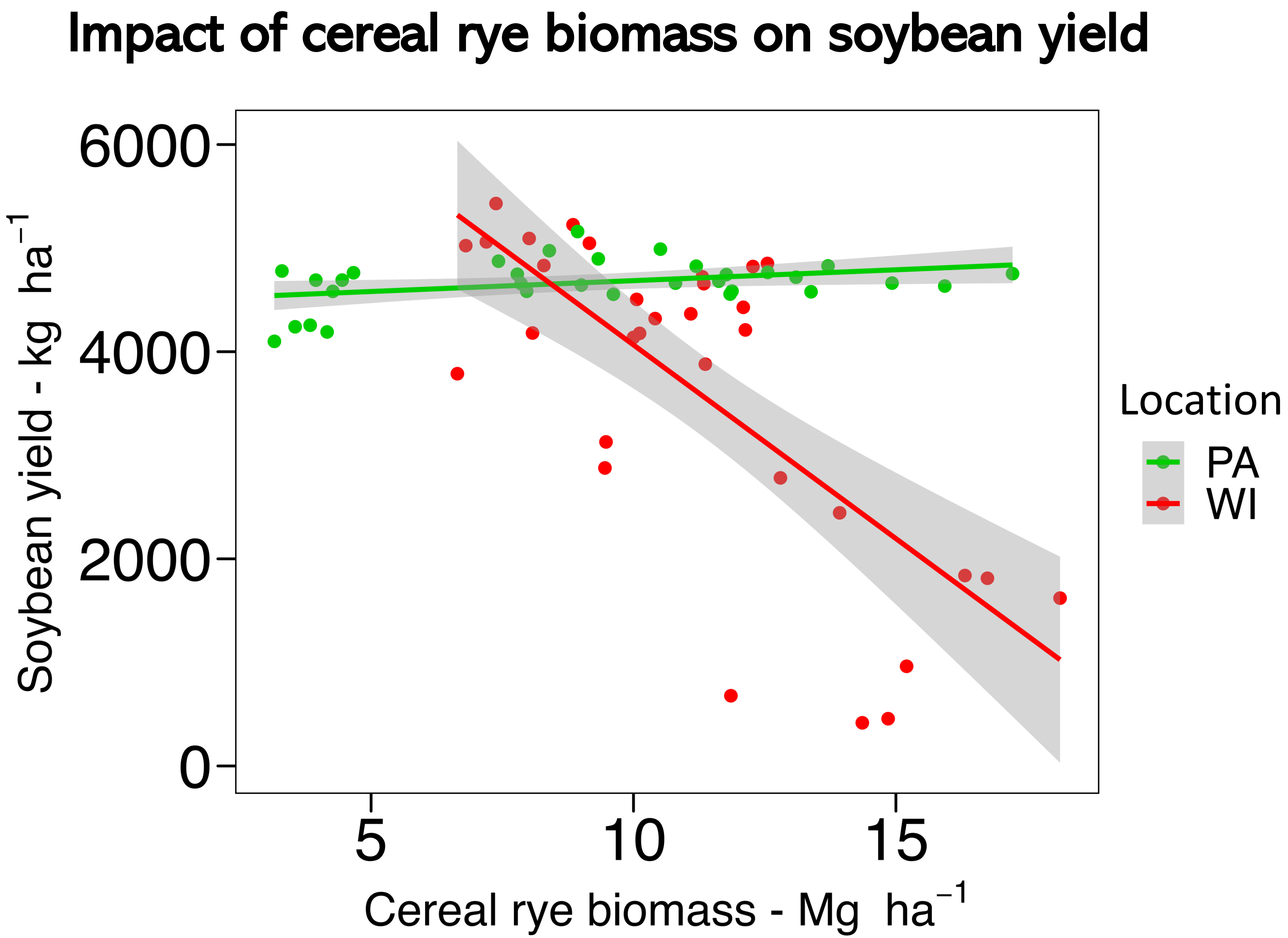
CC:S:L - *P* <0.001



CC: Cover crop management effect. S: Soybean planting time effect. L: Location effect
Error bars indicate the standard error of means

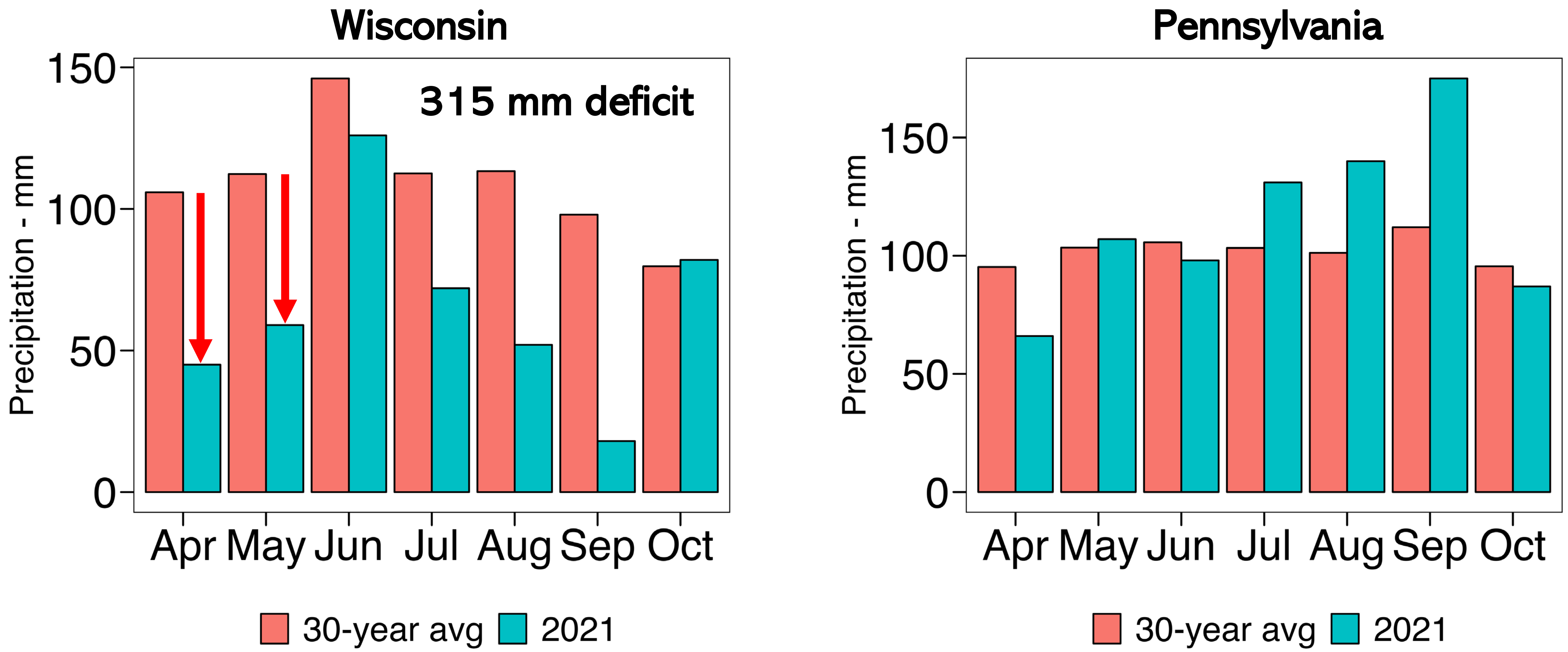

Is the cereal rye biomass having a negative effect on soybean yield?

Results | Soybean Yield



Results | Soybean Yield

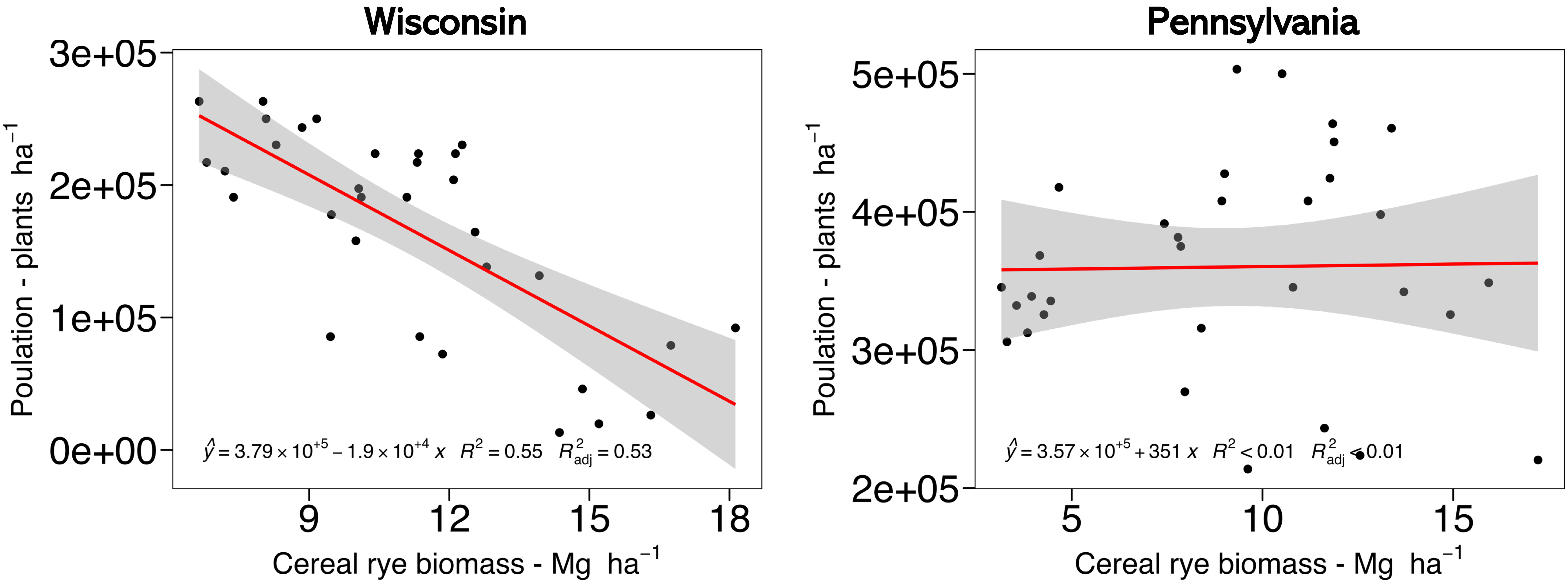
Precipitation (mm) during the growing season



30-year average (1990-2020) source: DAYMET

Results | Soybean Yield

Impact of cereal rye biomass on soybean population



Benefits ⚖ Challenges

Conclusions |

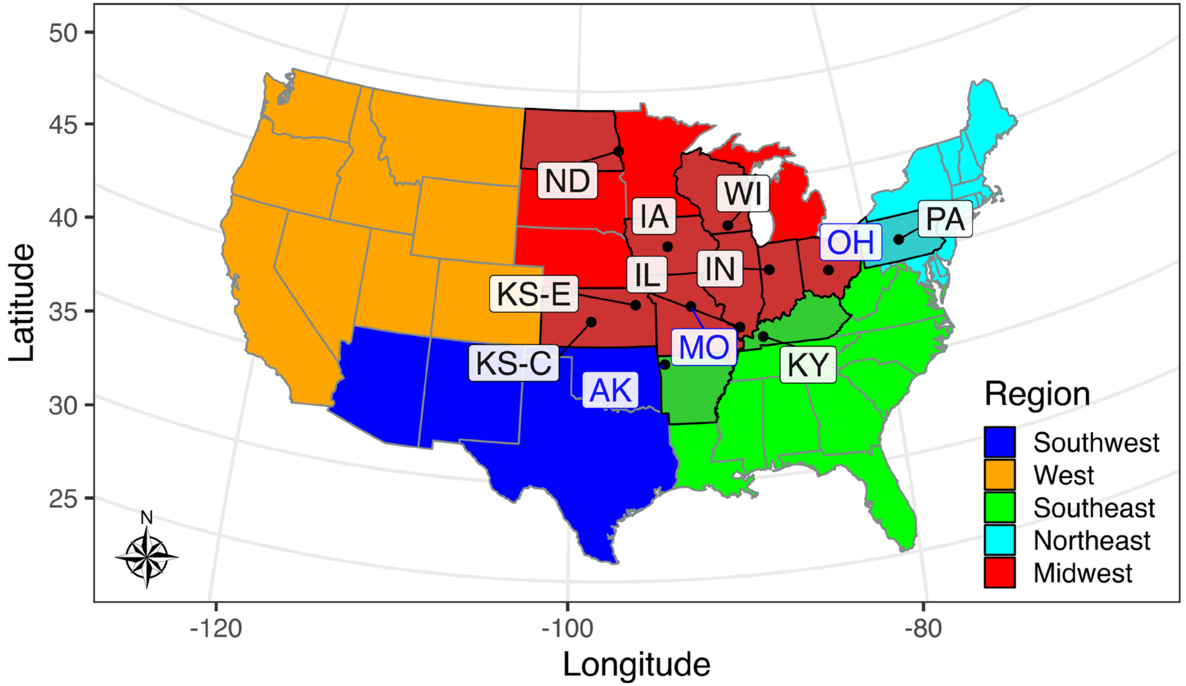
Planting green optimized cereal rye biomass accumulation and reduced waterhemp density

The use of PRE-emergence herbicides also played an important role in waterhemp control

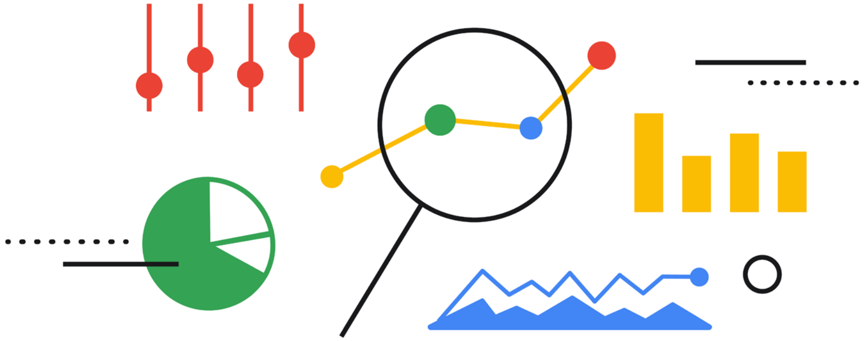
Soybean yield was not solely affected by cereal rye biomass accumulation

Future Directions |

The study was replicated in 2022



Data modeling



Moving forward…

Determine the critical time for cereal rye cover crop termination after soybean planting.

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SIU Southern Illinois University CARBONDALE
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WISCONSIN UNIVERSITY OF WISCONSIN–MADISON
PennState
KANSAS STATE UNIVERSITY
University of Kentucky
NDSU
USB UNITED SOYBEAN BOARD

Thank you!

Jose Nunes

jjnunes@wisc.edu

Check my poster #89 for more cereal rye cover crop research!

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Effect of Cereal Rye Cover Crop Biomass on Waterhemp Emergence and Soil Abiotic Parameters

Jose J. Nunes[1], Guilherme Chudzik[1], Arthur F. Teodoro[1], Nicholas J. Arneson[1], and Rodrigo Werle[1]

[1]Department of Agronomy, UW-Madison – Corresponding author's email: jjnunes@wisc.edu

INTRODUCTION

- Various studies have evaluated waterhemp (*Amaranthus tuberculatus* [Moq.] Sauer) suppression from cereal rye (*Secale cereale* L.) cover crop (CC) as part of weed management programs (Bish et al. 2021). Nevertheless, a limited number of experiments have investigated the effects of CC biomass on soil abiotic parameters (soil temperature, moisture, and light incidence) which can greatly influence waterhemp germination and emergence.

OBJECTIVE AND HYPOTHESIS

- **Objective:** Elucidate the effect of CC biomass on waterhemp emergence and soil abiotic parameters (temperature, moisture, and light incidence).
- **Hypothesis:** The increase in CC biomass can delay waterhemp emergence and reduce soil temperature and light incidence but raise soil moisture.

MATERIALS AND METHODS

➢ **Establishment**

- Dose-response field study (RCBD) with 4 replications conducted at two locations (Janesville & Brooklyn, WI) in 2022 (establishment May 30 and 31, respectively). Plots size: 0.91 by 2.13 m.
- CC biomass was harvested (at anthesis) and dried to constant weight at 60°C to meet the following doses of dry biomass: 0.0, 0.6, 1.2, 2.5, 4.9, 7.4, 9.9, and 12.4 Mg ha^{-1}. Biomass was evenly distributed over the plots.

➢ **Data collection and analyses:**

- **Light incidence (µmol m^{-2} s^{-1})** was measured at the soil surface (underneath CC biomass) at 0 DAE (days after establishment) with a manual LightScout Quantum Meter.
- **Waterhemp cumulative emergence (%)** was estimated by weekly counting and pulling all emerged seedlings from 7 to 70 DAE on a 0.1 m^{-2} quadrat demarked within each plot.
- **Soil volumetric water content (m^3 m^{-3} [0-7.6 cm soil depth])** was measured weekly from 7 to 70 DAE with a handheld time domain reflectometry FieldScout TDR 300 Meter.
- **Soil temperature (°C [7.6 cm soil depth])** was monitored under the doses of 0, 4.9, and 12.4 Mg ha^{-1} of CC biomass from 0 to 70 DAE with a Watchdog 1650 Micro Station.
- Data from the two locations were pooled.
- Non-linear regression models (*drc* package) were fit to light incidence and cumulative waterhemp emergence and a linear regression model to soil volumetric water content using R software (version 4.2.1).

RESULTS AND DISCUSSION

- CC biomass significantly delayed and reduced waterhemp emergence over time (Figure 1).
- Increase in CC biomass doses provided higher light interception and soil moisture (Figures 2 & 4). Moreover, there was lower temperature amplitude in the soil under the levels of 4.9 and 12.4 Mg ha^{-1} of biomass compared to the absence of CC (Figure 3).
- The interception of light (Figure 2) and lower temperature amplitude (Figure 3) are likely two important mechanisms of weed suppression by CC, given the importance of light and temperature for waterhemp emergence and development (Leon et al. 2004; Steckel et al. 2003). However, the increase in soil moisture under low cover crop biomass during dry weather spells can stimulate waterhemp emergence, as previously reported (Teasdale & Mohler, 2000).

CONCLUSIONS AND FUTURE DIRECTIONS

- CC biomass presented a strong effect on soil abiotic parameters which can help better understand waterhemp suppression mechanisms behind CC given its biology.
- The study will be replicated in 2023.
- Future studies to investigate the long-term effect of the CC biomass on weed seed fate in the soil in addition to validating the current findings with large-seeded broadleaf weed species.

University of Wisconsin-Madison

Bish et al. 2021. Effects of cereal rye seeding rate on waterhemp (*Amaranthus tuberculatus*) emergence and soybean growth and yield. Weed Technology, 35(5), 838-844.

Leon et al. 2004. Effect of temperature on the germination of common waterhemp (*Amaranthus tuberculatus*), giant foxtail (*Setaria faberi*), and velvetleaf (*Abutilon theophrasti*). Weed Science, 52(1), 67-73.

Steckel et al. 2003. Effects of Shading on Common Waterhemp (*Amaranthus rudis*) Growth and Development. Weed Science, 51(6), 898–903.

Teasdale & Mohler 2000. The Quantitative Relationship between Weed Emergence and the Physical Properties of Mulches. Weed Science, 48(3), 385–392.

Acknowledgments: We would like to thank the members of the UW-Madison Cropping Systems Weed Science for their technical assistance with study establishment and data collection.

WATERHEMP EMERGENCE

CC biomass > 2.5 Mg ha^{-1} delayed waterhemp emergence

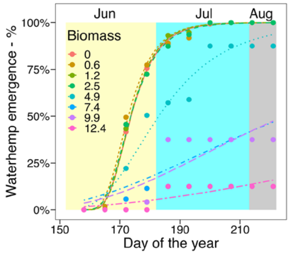

Figure 1: Waterhemp cumulative emergence over time.

LIGHT INTERCEPTION

0.7 Mg ha^{-1} intercepted 50% of the light reaching the soil level

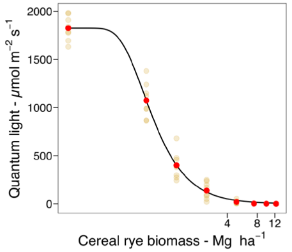

Figure 2: Quantum light at soil level in response to CC biomass at study establishment (0 DAE).

SOIL TEMPERATURE

Soil under CC biomass had lower temperature amplitude

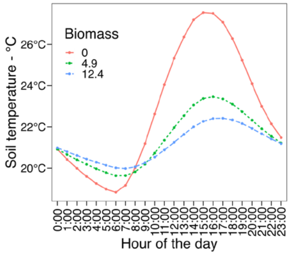

Figure 3: Average (0-70 DAE) hourly soil (0-7.6 cm depth) temperature under 0, 4.9, and 12.4 Mg ha^{-1} of CC biomass.

SOIL MOISTURE

The increase in CC biomass raised soil moisture

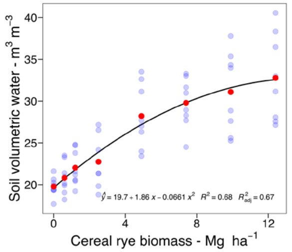

Figure 4: Average (7-70 DAE) soil volumetric water content (0-7.6 cm depth) in response to CC biomass.