# Mitigating Salinity Impact: Spring-Planted Winter Barley, Winter Rye, and Winter Camelina Cover Crops Boost Soybean Yield

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## Introduction

Soil salinity is a significant challenge in North Dakota, affecting over 1.9 million acres and reducing crop yields. Often marked by a white crust, saline soils have high soluble salts like sulfates, carbonates, and chlorides. Soils with electrical conductivity (EC) over 4 mmhos/cm are considered saline (Franzen et al., 2019; Seelig, 2000), but soybean yields can drop by 20-25% with EC levels above 1.1 mmhos/cm, reaching 50% loss at 2 mmhos/cm (Butcher et al., 2015).

Mitigating salinity in North Dakota relies on water management, reducing evaporation, and improving drainage. Cover crops can be used as a green cover to decrease soil surface evaporation and improve drainage through root channels. Additionally, cover crops can offer multiple benefits, such as crop diversity, reducing erosion, and improving soil health (Blanco-Canqui et al., 2015).

Winter cover crops need vernalization for anthesis, and because of that, spring-planted winter rye, winter camelina, winter barley, etc., remain in the vegetative stage, acting as green mulch in between the soybean rows, decreasing surface evaporation and adding root channels that increase soil water drainage. Adding a cover crop in the system also improves microbial communities' biodiversity. In North Dakota, winter rye has been used to mitigate the unfavorable impact of saline conditions in soybeans, where a significant increase in beneficial soil microbes was reported (Dasgupta et al., 2023). We hypothesized that winter cover crops, planted in early spring, would act as green mulch during the growing season, alleviating salinity problems and obtaining significantly higher soybean yields.

## Methodology

This research was conducted in Carrington, ND, under dryland conditions in a saline area with an electrical conductivity (EC 1:1) gradient ranging from 0.6 to 3 mmhos/cm. The trial followed a randomized complete block design (RCBD) with treatments including soybean (check), soybean with winter rye, winter barley, winter camelina, or a cover crop mix. Each cover crop was planted at 66% and 33% of the recommended seeding rate. The cover crop was either terminated at the R2 stage of soybeans or left in the field without termination. The experimental plot size was 10 ft by 25 ft. Cover crops were planted on May 5 and soybeans were planted by June 21, 2024. By June 25, the soil green cover was measured using the Canopeo App.

Before planting, the soil in the research area was mapped using an EM38 device to measure apparent electrical conductivity. This data was used to create an EC map in ArcGIS (Figure 1a), helping select areas with low variability and target specific EC levels for the study. Soil samples were then collected and analyzed for EC 1:1 and saturation paste to characterize the soil (Figure 1b).

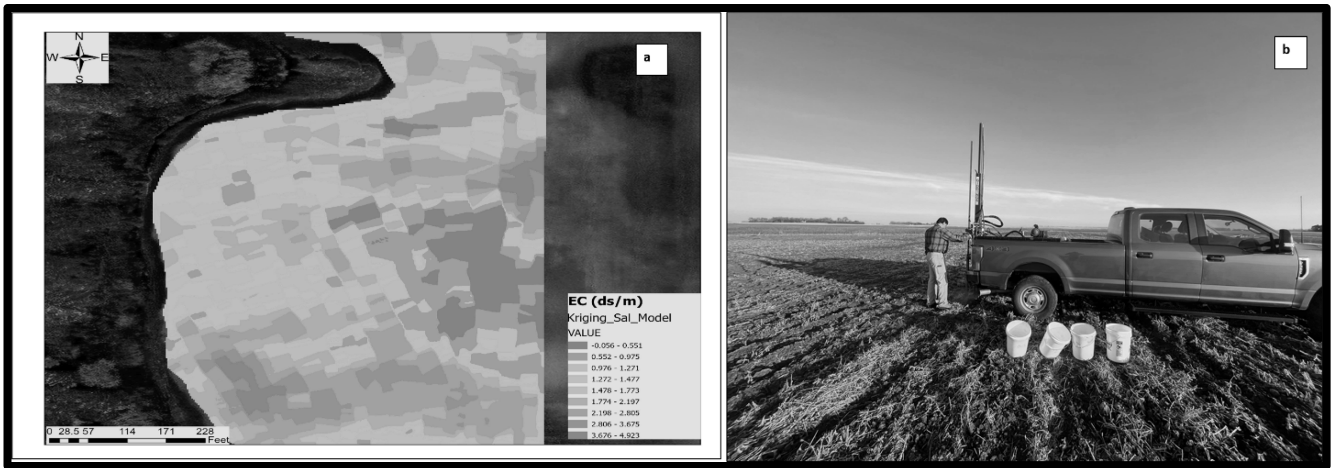


**Figure 1. (a) Soil electrical conductivity map from EM38, Carrington, ND, 2024. (b) Soil sampling for soil electrical conductivity characterization, Carrington, ND, 2024.**

Soil composite samples were collected at 0–6 inches and 6–24 inches depths in early spring. Topsoil samples (0–6 inches) were analyzed for nitrate-N ($NO_3$-N), pH, phosphorus (P), potassium (K), sulfate-S, zinc (Zn), EC, and organic matter, while deeper samples (6–24 inches) were tested for nitrate-N. Additional soil sampling for EC and pH was performed at the R2 soybean stage at the 0–6-inch depth per plot.

Cover crop biomass samples were taken mid-season from a 3.3-foot section of an internal row at the soybean R2 stage. These samples were dried and weighed to calculate biomass production. Above-ground soybean biomass was also sampled at this time. Before soybean harvest, biomass samples were collected again from plots where glyphosate was not sprayed.

Grain yield, test weight, protein, and oil content were measured at soybean harvest to evaluate treatment effects.

**Results**

Spring temperatures were cool, and rainfall was 15% above average, ensuring good moisture throughout the growing season. However, frequent rains made it challenging to plant cover crops and soybeans on time.

Winter barley, winter rye, and the cover crop mix achieved the highest green cover values, exceeding 30%, and provided effective mulch during the early stages of soybean growth (Figure 2a). Soybean plants reached the R2 stage by July 25, when cover crop biomass was sampled. Winter camelina and the cover crop mix, seeded at 66% of the recommended rate, produced significantly higher biomass, averaging over 2,000 pounds per acre (Figure 2b).

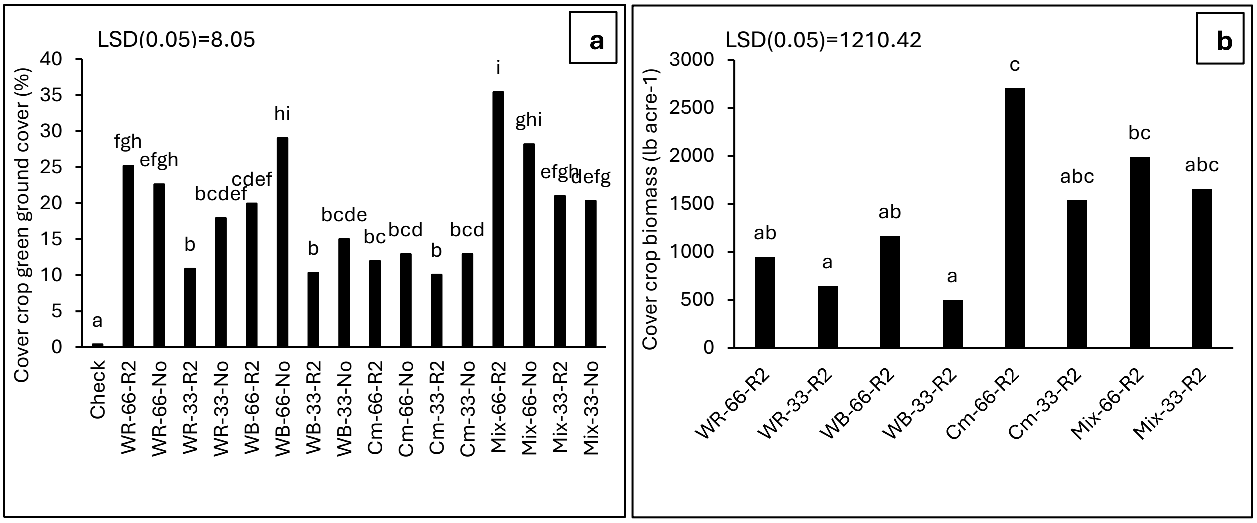


**Figure 2. (a) Cover crop green ground cover on June 27, 2024, Carrington, ND. (b) Cover crop biomass at soybean R2 stage, July 25, 2024, Carrington, ND. Abbreviations: WR = winter rye; WB = winter barley; Cm = winter camelina; Mix = WR+WB+Cm; Check = no cover crop; 66 = 66% of recommended cover crop seeding rate; 33 = 33% of recommended cover crop seeding rate; R2 = cover crop termination date at soybean R2 stage; No = no termination for cover crops. Bars with different letters are statistically different at alpha = 0.05.**

Soil salinity had a severe impact on soybeans. When EC (1:1) was above 1.8 mmhos/cm, soybean yields dropped by more than 50% compared to fields with EC levels of 0.63 mmhos/cm. Figure 3b illustrates soybean yield responses to different salinity levels, with each level represented as a block in the RCBD field design. Figure 3a shows an aerial photo of the Soybean Green Index, highlighting each replication's average EC (1:1) values. Soybean biomass was notably higher in areas with low soil salinity, as expected, while higher salinity levels resulted in poor plant stands and reduced biomass.

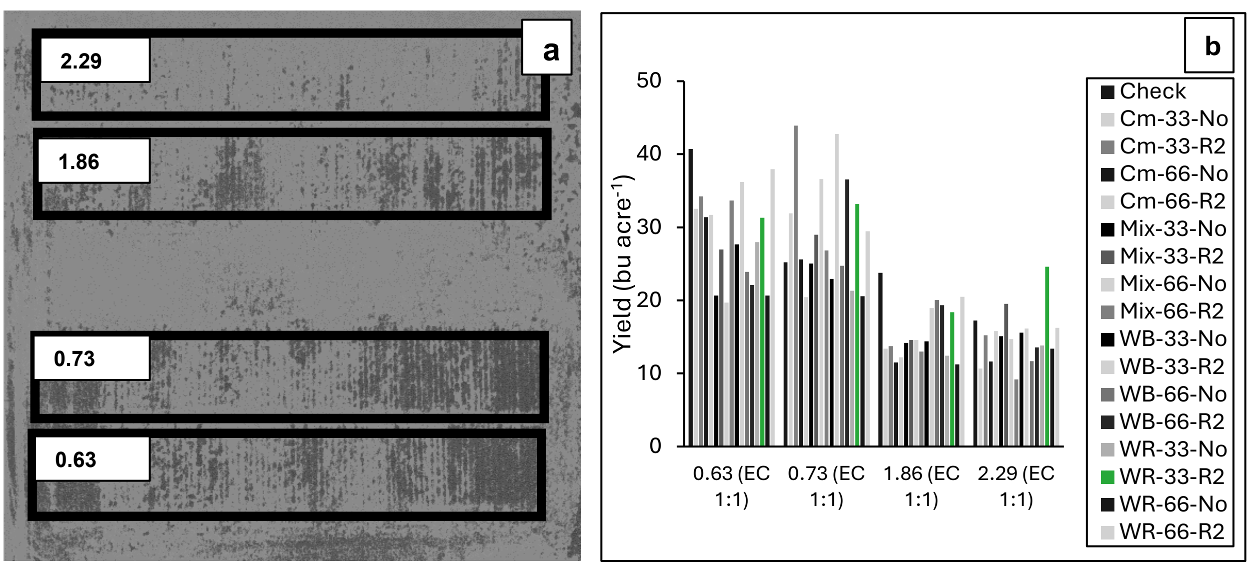


**Figure 3. (a) Soybean Green Index aerial photo with average EC (1:1) per replication, Carrington, ND, 2024. (b) Soybean grain yield across four soil EC (1:1) levels, each level represents a replication on the field, Carrington, ND, 2024. Abbreviations: WR = winter rye; WB = winter barley; Cm = winter camelina; Mix = WR+WB+Cm; Check: = no cover crop; 66 = 66% of recommended cover crop seeding rate; 33 = 33% of recommended cover crop seeding rate; R2 = cover crop termination date at soybean R2 stage; No = no termination for cover crops.**

Soybean grain yield varied across treatments with spring-planted cover crops. Winter camelina, barley, and rye outperformed the check plot (no cover crop) by 2-3 bushels per acre, representing a 5-8% increase (Figure 4). However, these differences were not statistically significant. Nonetheless, these results provide a promising foundation for refining cover crop seeding rates and termination timing. In Figure 4, we can see that soybean yield was 33% higher in treatments where cover crops were seeded at 33% of the recommended rate and terminated at the soybean R2 stage, compared to treatments where the cover crop seeding rate was 66% with no termination date.

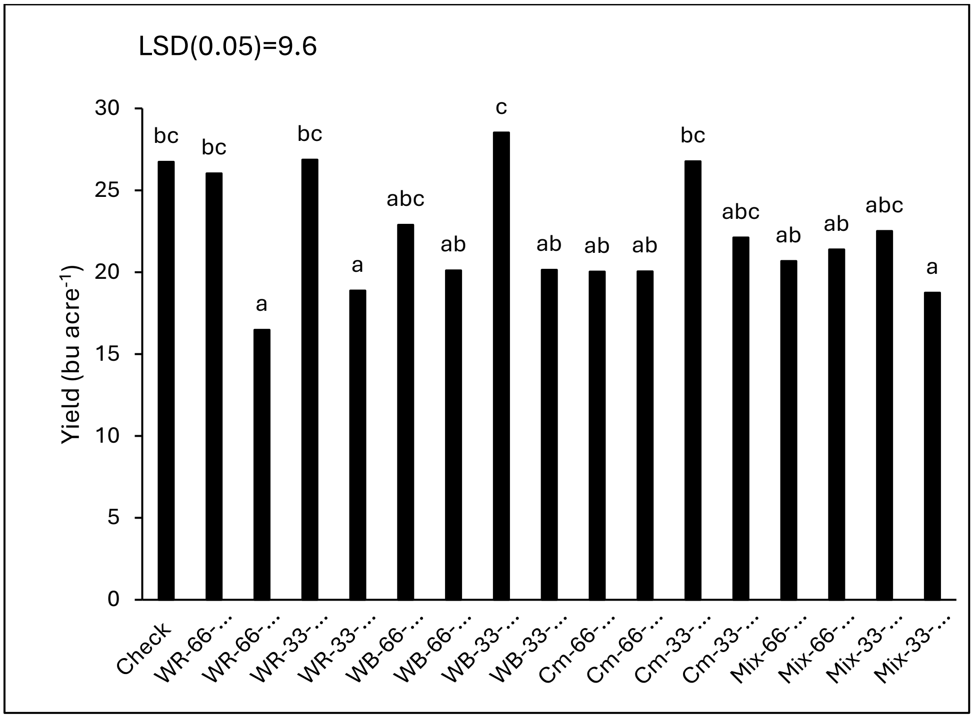


**Figure 4. Soybean grain yield under different cover crop treatments, Carrington, ND, 2024. Abbreviations: WR = winter rye; WB = winter barley; Cm = winter camelina; Mix = WR+WB+Cm; Check = no cover crop; 66 = 66% of recommended cover crop seeding rate; 33 = 33% of recommended cover crop seeding rate; R2 = cover crop termination date at soybean R2 stage; No = no termination for cover crops. Bars with different letters are statistically different at alpha = 0.05.**

## Conclusions

The 2024 Carrington study found that planting winter barley, winter rye, and winter camelina one month before soybeans increased yields by 5–8%. While the yield differences were not statistically significant, the results suggest a potential benefit for mitigating salinity and enhancing soybean yields.

In saline soils, soybean yields may decline further if the cover crop seeding rate exceeds 33% of the recommended rate and/or if cover crops are terminated after the soybean R2 growth stage. These findings are a valuable starting point for optimizing cover crop seeding rates and termination timing for soybean production, but further research is needed to draw reliable conclusions.

## Acknowledgments

*Partial funding for this project was provided by the North Dakota Soybean Council, https://ndsoybean.org/*

## References

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