COVER CROP COMPOSITION: IMPLICATIONS FOR CROP YIELDS, NITROGEN USE AND SOIL HEALTH IN CORN-SOYBEAN ROTATIONS

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ABSTRACT

Cover crops can improve agricultural sustainability by influencing N (N) use, enhancing soil health, and optimizing crop yields. However, their effects may vary based on species composition. This study evaluated how different cover crop compositions impact crop yields, N requirements, and soil health in corn-soybean rotations. Field experiments were conducted at Brookings and Beresford, South Dakota. Three cover crops (none, single grass, and multi-species) were interseeded at the V6 stage in corn and V5 in soybean. Six N rates ranging from 0 to 250 $lb.ac^{-1}$ were applied 10 days after planting in corn. Soil samples collected from the 0-6" depth at V6, R1, and R6 stages were analyzed for active carbon, aggregate stability, organic carbon, organic matter, potentially mineralizable N (PMN), NO3 – N, and NH4 – N. On average, interseeding cover crops in corn required 10-15 $lb.ac^{-1}$ more N than no cover crop, with the grass cover crop requiring ~10 $lb.ac^{-1}$ more N than the mixed species. At the economic optimal N rate, yield differences were minimal; the grass cover crop increased yield by only ~0.03 $bu.ac^{-1}$ and mixed species reduced yield by ~0.08 $bu.ac^{-1}$ compared to the control. These results suggest that interseeding cover crops in corn slightly alters yields but remains feasible with proper N management, while soybean yields remain unaffected, supporting interseeding as a viable practice. Interseeding cover crops had minimal impact on measured soil health parameters, likely due to insufficient biomass production. Conversely, higher N rates enhanced PMN, NO3 – N, and NH4 – N, reflecting increased nutrient availability. Sample timing influenced organic matter, active carbon, and aggregate stability. Overall, this study shows that cover crops regardless of composition can be interseeded into soybean without yield effect, but corn requires more N to sustain yields. Further, four years of interseeding cover crops into corn and soybean was not sufficient to find measurable differences in the selected soil health measurements.

INTRODUCTION

Corn-soybean rotations dominate agriculture in the U.S. Midwest, but this narrow crop diversity can limit biodiversity and compromise long-term soil health. To address these issues, cover crops are increasingly incorporated to enhance sustainability through greater species diversity, improved soil quality, and more efficient nutrient cycling. Cover crops can boost N use efficiency, soil health, and crop productivity, although the benefits depend on factors like species selection, timing, and management practices (McDaniel et al., 2014; Tiemann et al., 2015). However, widespread adoption is limited by high costs, return-on-investment concerns, and challenges with establishment, especially in areas with shorter growing seasons (Wayman et al., 2017).

Despite these obstacles, cover crop use has surged recently, with U.S. adoption growing 50% between 2012 and 2017, though they still occupy a small fraction of farmland (Thompson et al., 2021). In the northern Midwest, shorter growing seasons pose additional constraints, favoring winter cereals as cover crops despite challenges with their establishment timing (Baker & Griffis, 2009). Commonly interseeded species include grasses, clovers, and Brassicas (USDA ERS - Cover Crops, 2021). Combinations like annual ryegrass and crimson clover, both individually and in multispecies mixes, are being explored to find options that balance environmental benefits with crop productivity.

A primary concern with interseeding cover crops in corn is potential competition, particularly for N, which could impact corn yields (Hall et al., 1992). Studies by Travlos et al., 2011 indicate that competition with corn is minimal when weeds emerge after growth stages V2 to V5, suggesting that cover crops interseeded as early as V2 may not affect corn yields. However, the competitiveness of cover crops varies by species and density, influencing N needs for optimal yields. This study examines how single and multispecies cover crops, impact soil health, N requirements, and yields in corn-soybean rotations.

MATERIALS AND METHODS

In 2019, a long-term study was initiated in Brookings and Beresford, South Dakota utilizing a corn-soybean rotation. The study employed a split-plot design within each crop area. The main plot consisted of three cover crop treatments: no cover crop, a single grass species, and a mixture of grass and broadleaf species. The subplots included N fertilizer rates, with four or six levels ranging from 0 to 250 lb-N.ac^{-1}, applied 7–10 days after planting. Ammonium nitrate or Super U served as the N source, and cover crops were interseeded at the V5 developmental stage of both corn and soybean.

Soil, plant and grain sampling

Soil samples were collected before planting from plots previously under corn and transitioning to soybeans, at depths of 0–6” and 6–24”. The 0–6” soil samples were analyzed for soil health and fertility, while the 6–24” samples were tested for ammonium-N, nitrate-N, and sulfur content (Table 1). In-season soil samples were collected at key developmental stages: V6, R1, and R6 for corn, and V5, R1, and R6 for soybean. These samples were analyzed for soil health and fertility indicators (Table 1). Post-harvest, soil samples were taken at depths of 0–12”, 12–24”, and 24–36” to assess residual nitrate-N levels following the growing season (Table 1).

Plant samples were collected at specific developmental stages: V6, R1, and R6 for corn, and V5, R1, and R6 for soybean. For corn, six plants were sampled at each stage, while soybean samples were collected from a 1 m² area. At harvest, grain samples were taken and analyzed for complete nutrient content.

Table 1. Summary of soil sampling stages, depths, and parameters analyzed.

Sample Type	Collection Time	Sampling Depth	Measurements
Soil	Pre-plant	0-6”	Nitrate-N, Ammonium-N, Soil Organic Matter, Organic Carbon, Active C, PMN, Wet Aggregate Stability
		6-24”	Ammonium-N, Nitrate-N, Sulfur (S)
Soil	In-season	0-6”	Nitrate-N, Ammonium-N, Soil Organic Matter, Organic Carbon, Active C, PMN, Wet Aggregate Stability
Soil	Post-Harvest	0-12”	Nitrate-N
		12-24”	
		24-36”	

RESULTS AND DISCUSSION

Corn Yield Response and N requirements

Corn yields and N requirements varied across cover crop treatments at the Beresford and Brookings locations. At Beresford, the grass cover crop consistently had the highest EONR of up to 113 lb.ac^{-1}, while the no cover and mix treatments had lower N requirements, averaging around 47–78 lb.ac^{-1}. Despite increased N needs, the grass treatment maintained stable yields at EONR, averaging 165–199 bu.ac^{-1}, while the no cover treatment showed consistently higher yields of 176–206 bu.ac^{-1} with less N, indicating more efficient N use. The mix treatment demonstrated intermediate N needs, with EONRs around 77 lb.ac^{-1} and slightly lower yields averaging 204 bu.ac^{-1}. At Brookings, the grass treatment also required higher N inputs, with EONR reaching about 120 lb.ac^{-1} in 2019, while no cover and mix treatments required lower EONR values of around 45–85 lb.ac^{-1}. Yields at EONR were stable across treatments at Brookings, with the no cover treatment averaging 175–200 bu.ac^{-1}, and grass yielding slightly less, around 160–190 bu.ac^{-1}.

Overall, these results emphasize the importance of aligning cover crop selection with N management goals in corn. The grass treatment, while more N-intensive, may enhance sustainability by providing stable yields and potentially benefiting soil health through increased organic matter and labile carbon. Conversely, the no cover treatment's efficiency could support reduced input strategies, particularly in regions where minimizing N application is economically or environmentally advantageous. These insights contribute to the broader understanding of how cover crop choices can impact N optimization and yield outcomes, providing valuable guidance for designing efficient and sustainable corn-soybean rotation systems.

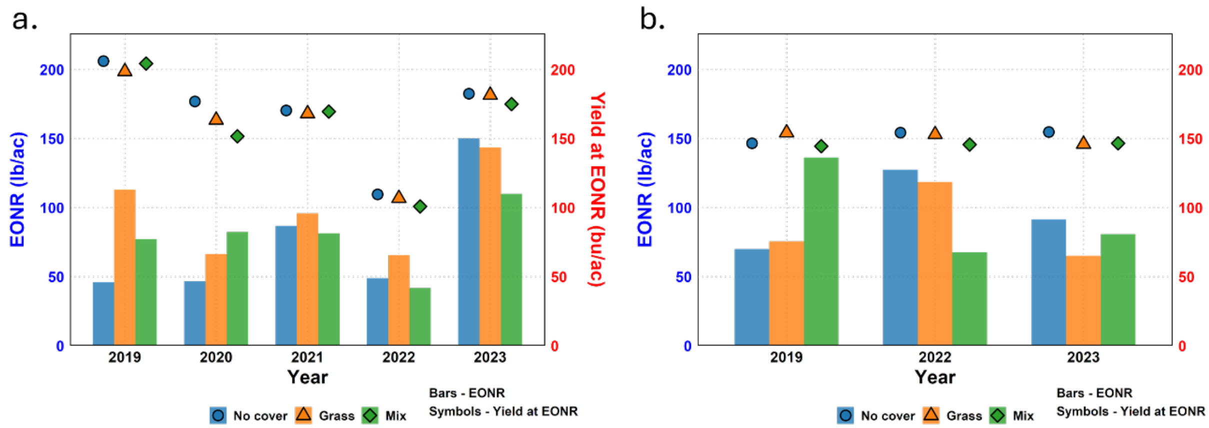

Figure 1. Economic Optimum Nitrogen Rate (EONR) and Corn Yield at EONR Across Years and Cover Crop Treatments at a) Beresford and b) Brookings

Soybean Yield Response

Soybean yields across cover crop treatments showed minor variations but generally stable trends at both the Beresford and Brookings locations (Figure 2). At Beresford, the grass and mix treatments produced slightly lower yields, averaging around 45 bu/ac, while the no cover treatment yielded slightly higher, with an average close to 46 bu/ac. At Brookings, similar patterns were observed, with all treatments yielding consistently over the years. Despite minor fluctuations, particularly with the mix treatment, there were no substantial differences among treatments, suggesting that the use of cover crops (grass or mix) did not significantly impact overall soybean productivity compared to the no cover treatment.

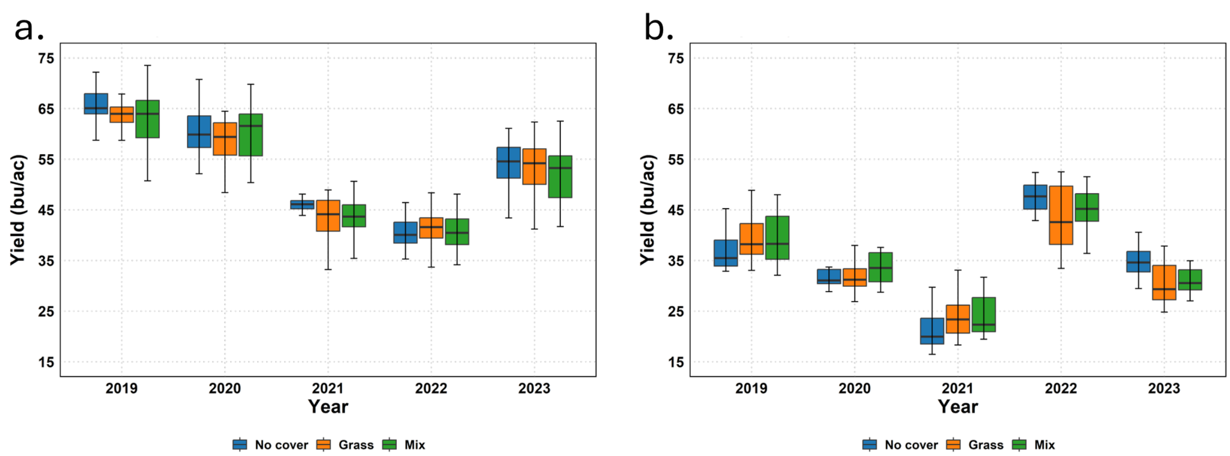

Figure 2. Soybean Yield Across Years and Cover Crop Treatments at a) Beresford and b) Brookings.

Soil health responses

The analysis of soil health variables, though initially revealing trends across cover crops, N rates, and sample timing, showed no statistically significant differences for any cover crop treatment across all measured soil health metrics. Organic Matter (OM) and Organic Carbon (OC) levels remained stable across treatments, with slight increases observed in plots with higher N rates, reaching up to 3.8% for OM and 2.2%

for OC, suggesting that while cover crops and N application may support organic content, these changes were not statistically significant. Active Carbon (Active C) displayed higher values in cover-cropped plots, particularly with single-species covers, reaching around 400 ppm. Variations in Active C over the season (dropping to around 250 ppm later in the season) point to progressive carbon utilization, yet again without significant distinctions across treatments.

Potentially Mineralizable Nitrogen (PMN) levels tended to increase in higher N rate plots, particularly early in the season, with values reaching up to 70 ppm, suggesting boosted microbial activity from N inputs, although cover crop treatment effects remained statistically nonsignificant. Similarly, Aggregate Stability (Agg Stab) showed slight improvements with cover crops and higher N rates, ranging between 13% and 21%, but with no statistically significant effect from cover cropping. Nitrate-N and Ammonium-N concentrations were also most responsive to elevated N rates, reaching 20 ppm and 15 ppm respectively at early sample timings, but these results did not show significant differences among cover crop treatments. Overall, these results suggest that while cover crops and N applications appear to influence soil health trends, no significant differences were detected, indicating that longer-term studies may be needed to observe measurable effects from cover cropping on soil health.

CONCLUSIONS

This study underscores the nuanced role of cover crops and N management in shaping both crop yield and soil health within a corn-soybean rotation system. Although cover crops like grass species require slightly higher N inputs for optimal corn yields, they offer stable productivity and support soil health by enhancing labile carbon and improving soil structure. The minimal impact of cover crops on soybean yield suggests that soybean may be a resilient crop choice within rotational systems using cover crops, as its productivity remains consistent across site-years.

The findings also highlight the importance of sample timing on soil measurements, as early-season N applications contribute significantly to nutrient availability and microbial activity, with decreasing levels as the season progresses. Overall, this work emphasizes that efficient N use, and targeted cover crop choice can align with sustainable agricultural practices, allowing for productivity without compromising soil quality. As agricultural systems move toward more sustainable models, these insights can inform decisions that balance productivity goals with long-term soil health, offering a framework for resilient and resource-efficient cropping systems in the Midwest.

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