IMPACT OF COVER CROP COMPOSITION IN NITROGEN APPLICATION RATES AND THE SUBSEQUENT YIELDS OF CORN AND SOYBEAN

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ABSTRACT

Interseeding cover crops presents a promising strategy for enhancing the sustainability of agricultural systems. Nevertheless, the practice of interseeding cover crops introduces a dynamic element to nitrogen (N) cycling, potentially altering both the quantity and timing of N release through decomposition (mineralization). This variability in N availability may, in turn, influence the optimal nitrogen fertilizer requirements to maximize corn grain yield. However, long-term studies are essential to comprehensively assess the influence of cover crops on crop yields, as short-term investigations may not capture the full scope of soil and environmental factors. Therefore, a long-term study was initiated in South Dakota, encompassing two locations (Brooking and Beresford) within a corn-soybean rotation to explore the impact of cover crop composition on N fertilizer requirements and subsequent yields of corn and soybean. The study employed a split-plot design with three cover crop treatments (no cover crop, single grass species, multi-species - a mixture of grasses and broadleaf species) and 4-6 N rate treatments ranging from 0-250 lbs./acre. Results from 2019-22 indicate that corn with grass cover crop required anywhere from 10 lbs./ac less to 70 lbs./ac more N compared to no cover crop. In 2 of 6 N responsive site years, including a grass/broadleaf cover crop reduced corn yield at EONR (Economical Optimum Nitrogen Rate) by approximately 10 bu/ac compared to the grass or no cover crop treatments. Corn with grass cover crop compared to the grass/broadleaf mix and no cover crop yielded anywhere from 10 bu/ac less to 10 bu/ac more at EONR. In conclusion, interseeding grass cover crops into corn enhances corn yield and reduces N requirements. Furthermore, interseeeding of cover crops, both grass and grass/broadleaf mixes, into soybeans has no adverse effects on soybean yield.

INTRODUCTION

Corn production and productivity in South Dakota have steadily increased over time. However, this heavy reliance on a limited number of crops can lead to reduced agricultural biodiversity. Interseeding cover crops into a corn-soybean rotation system have the potential to improve the biodiversity in these systems. Such rotations enhance soil biodiversity, nutrient availability, resource use efficiency, and soil organic matter (McDaniel et al., 2014; Tiemann et al., 2015). The inclusion of cover crops has become increasingly popular in corn (Zea mays L.) and soybean (Glycine max L. Merr.) rotations in the US Midwest. Cover crops offer additional benefits, including improved soil quality, pest control, and biological nitrogen fixation (Schipanski et al., 2014).

The recent surge in the use of cover crops can be attributed to their potential to enhance soil and water quality (Thompson et al., 2021). Between 2012 and 2017, there was a 50 percent increase in the adoption of cover crops in the US. However, this adoption still represents only a small fraction of the total cultivated area. Several factors currently limit the widespread adoption of cover crops, including high seeding costs, concerns about return on investment, insufficient breeding efforts and variety improvement, and difficulties in achieving successful cover crop establishment (Wayman et al., 2017). The northern Midwest faces particular challenges due to its shorter growing season, which limits the options for cover crop seeding after corn harvest. Winter cereals are the primary choice for cover crops in this region, but their establishment is constrained by the limited growing season (Baker & Griffis, 2009). Grasses are the most commonly interseeded species, followed by clovers and Brassica species (USDA ERS - Cover Crops, n.d.). Researchers have explored interseeding various cover crop species, including annual ryegrass (Lolium multiflorum Lam.) and crimson clover, both as single species and in mixtures.

One major concern associated with interseeding cover crops is competition with the main crop, in this case, corn (Hall et al., 1992). The competitiveness of weeds in corn depends on factors such as the timing of weed emergence relative to corn emergence, weed species, and weed density. It has been observed that weeds are not competitive with corn when they emerge after the V2 or V4 corn growth stages (Travlos et al., 2011), or even as late as the V5 stage. This suggests that cover crops could potentially be interseeded in corn as early as the V2 stage without negatively impacting corn grain yields. However, the competitiveness of cover crops, like weeds, may vary depending on the species and density of the cover crop. While cover crops do not compete with corn plants after the V5 stage, they can still affect the N requirements for optimal corn yields. Therefore, it is crucial to understand how different cover crop compositions influence soil biological measurements, N requirements for corn, and the yields of both corn and soybeans. This study aims to explore the effects of cover crop composition (both single and multispecies) on these important factors.

MATERIALS AND METHODS

In 2019, a long-term study was established in Brookings and Beresford, South Dakota in a corn-soybean rotation with both crops being present each year. The study utilized a split-plot design within each corn and soybean area. The whole plot included three distinct cover crop treatments: No cover crop, a single grass species, and a mixture of grass and broadleaf cover crops. The split-plot was N fertilizer rate with four or six N rates ranging from 0 to 250 lbs. N/acre. Ammonium Nitrate or Super U served as the source of N. Nitrogen fertilizer treatments were applied 7-10 days after planting and cover crops were interseeded when the corn and soybean plants reached the V5 developmental stage.

Soil sampling

Prior to planting, soil samples were collected from the treatment plots that were previously under corn and transitioning to soybeans at two depths: 0-6” and 6-24”. The 0–6” samples were subjected to analyses pertaining to soil health and fertility, while the 6-24” samples were analyzed for ammonium, nitrate, and sulfur content (Table 1). In-season soil samples were collected at specific developmental stages. For corn, these stages included V6, R1, and R6, while for soybeans, they encompassed V5, R1, and R6. The in-season soil samples were analyzed for soil health and fertility measurements (Table 1.) Post-harvest soil samples were obtained from three different depths: 0-12”, 12-24”, and 24-36”. These samples were analyzed to determine the remaining nitrate-N content in the soil after the conclusion of the growing season (Table 1).

Plant and grain sampling

Plant samples were collected at specific developmental stages. For corn, these stages included V6, R1, and R6, while for soybeans, they encompassed V5, R1, and R6. In corn six plants were collected at the above-mentioned growth stages. In soybean plans from 1m^2 were collected at the above-mentioned growth stages At harvest, grain samples were obtained and analyzed for complete nutrient analysis.

<table>
<tr><th>Sample type</th><th>Collection time/stage</th><th>Sampling depth/type</th><th>Measurements</th></tr>
<tr><td rowspan="2">Soil</td><td rowspan="2">Pre-plant</td><td>0-6”</td><td>Nitrate-N
Ammonium-N
Soil Organic matter
Organic Carbon
Active C
Potentially mineralizable N (PMN)
Wet aggregate stability</td></tr>
<tr><td>6-24”</td><td>Ammonium-N
Nitrate-N
S</td></tr>
<tr><td>Soil</td><td>In-season</td><td>0-6”</td><td>Nitrate-N
Ammonium-N
Soil Organic matter
Organic Carbon
Active C
PMN
Wet aggregate stability</td></tr>
<tr><td rowspan="3">Soil</td><td rowspan="3">Post- Harvest</td><td>0-12”</td><td rowspan="3">Nitrate-N</td></tr>
<tr><td>12-24”</td></tr>
<tr><td>24-36”</td></tr>
</table>

Table 1. Soil sample collection and parameters under investigation

RESULTS AND DISCUSSION

Corn Yield Response and N requirements

Corn yields responded to N fertilization in six out of eight site-years (Figure 1). The lack of response observed in the remaining site-years can be attributed to corn lodging due to strong winds and drought-induced potassium (K) deficiency in corn.

The results spanning from 2019 to 2022 revealed that corn grown with a grass cover crop required N ranging from 40 lbs./acre less to 25 lbs./acre more when compared to corn without any cover crop (see Figure 1a-f). In four out of six site-years where there was a response to N, the inclusion of a grass/broadleaf cover crop led to a reduction in corn yield at the Economical Optimum N Rate (EONR) by 15-30 bu/acre, in contrast to the grass-only or no cover crop treatments. Conversely, incorporating a grass cover crop significantly increased corn yield by 15 to 30 bushels per acre at the EONR compared to both the grass/broadleaf mix and no cover crop treatments, all while requiring less N and without any significant yield losses.

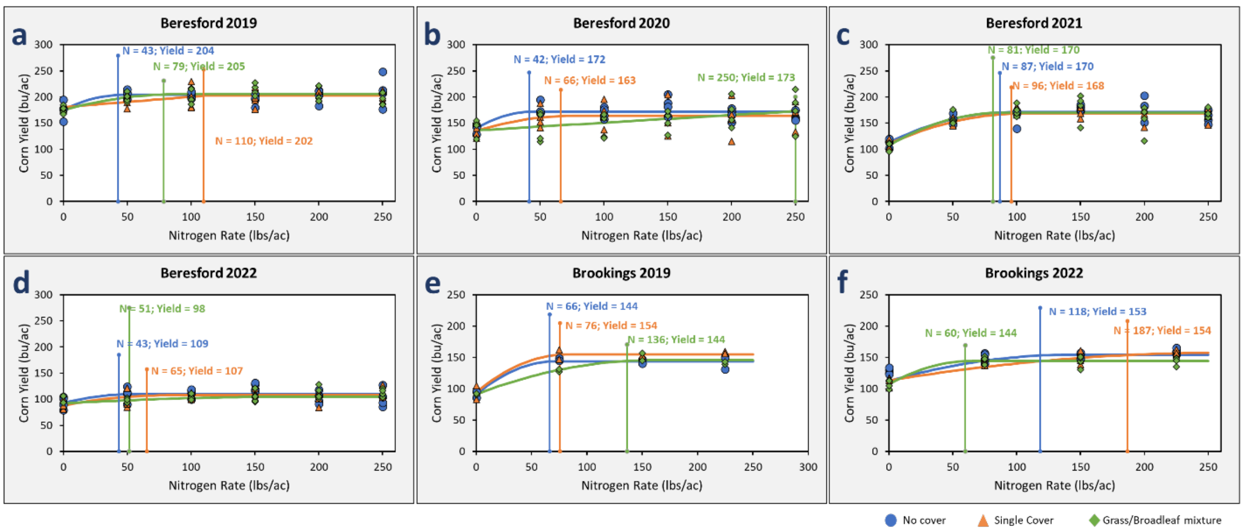

Figure 1. Corn yield response as a function of N rates across the cover crop treatments.

Soybean Yield Response

Across different N rates applied in the previous corn year, there were no significant differences in soybean yields among the cover crop treatments, except for at the Beresford site in 2021 (see Figure 2a-d). These findings suggest that, for soybeans, interseeding either grass or a mixture of grass and broadleaf cover crops had minimal to no impact on soybean yield. Therefore, it is reasonable to interseed cover crops into soybeans without affecting yield.

However, at the Beresford site in 2021, there was a trend towards reduced yields with interseeded single or cover crop mixtures at 50 and 100 lbs. N/acre rates from the previous year (see Figure 2b). This trend could be attributed to the drought conditions experienced during 2021, which may have played a role in the reduction in yields when cover crops were planted. Nevertheless, it's worth noting that the 2021 Brookings site also faced drought conditions, yet the inclusion of cover crops did not influence soybean yield. As we gather more data from various site years under different moisture conditions, our understanding of how interseeded cover crops affect soybean yield will continue to grow.

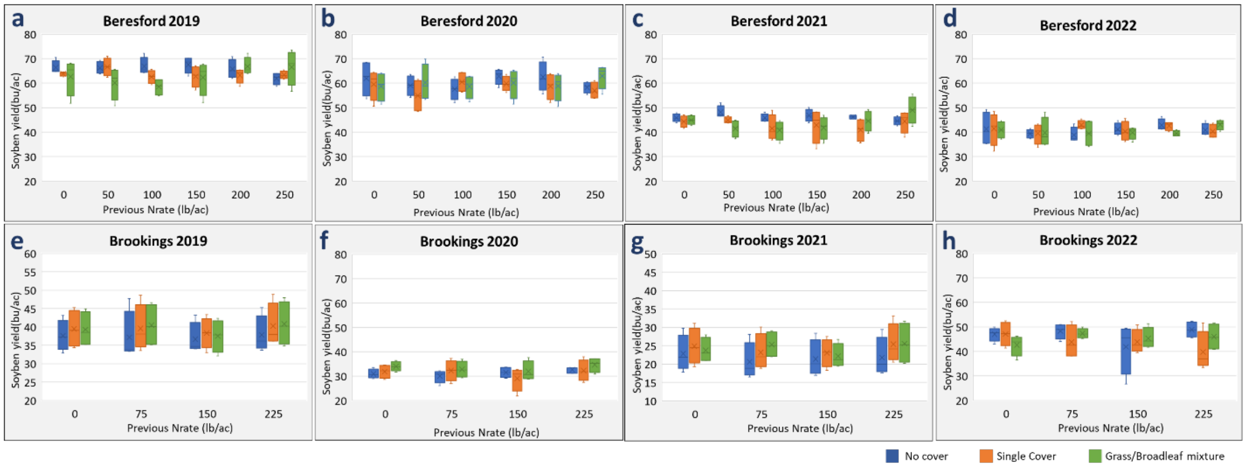

Figure 2. Soybean yield response as a function of previous N rates across cover crop treatments.

CONCLUSIONS

Interseeding cover crops into the corn-soybean rotation has the potential to bring about various direct and indirect benefits to overall soil health and fertility, all while maintaining crop yields. It's been observed that both single and multiple cover crop mixtures can be successfully interseeded into soybean without causing any adverse impact on yield. However, when it comes to the influence of cover crop composition on corn yields and N requirements, the results have been inconsistent during the initial three years of this study. Consequently, we need to gather additional data before we can draw definitive conclusions regarding the impact of cover crop composition on N requirements and corn yield.

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