JOINT – TRACKING CEREAL RYE RESIDUE NITROGEN RELEASE THROUGH SOIL POOLS AND CASH CROP UPTAKE – YEAR TWO

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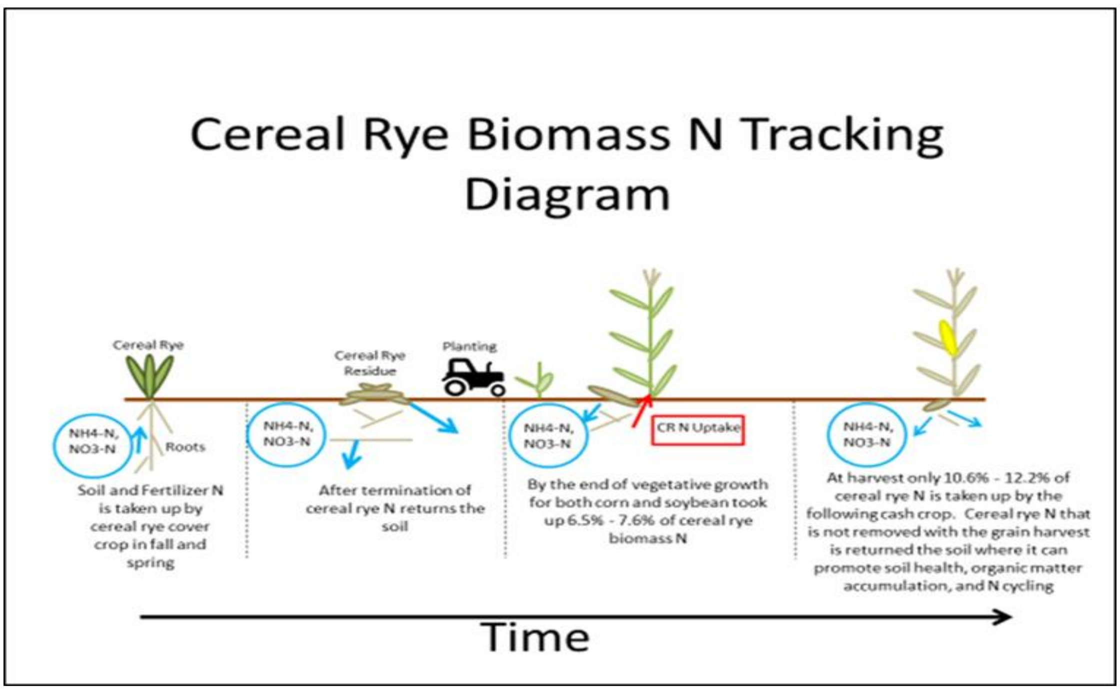
Introduction:

Cover crops have re-emerged nationally as a possible solution to reduce nitrogen (N) loading from agricultural fields and to increase soil health. However, currently in the Midwest less than 5% of agricultural land has received cover crops. The integration of cover crops into a farmer's existing N management system requires three considerations before mass voluntary adoption can occur, (1) can cover crops reduce the amount of fertilizer N lost; (2) what percentage of cover crop scavenged N will be available to the next crop; and (3) how does the timing of cover crop residue N release correlate with the N demand of corn and soybeans? Therefore, the objectives of our study were to utilize ^{15}N techniques to measure the amount of cereal rye residue N utilized by the subsequent corn and soybean crop and to quantify the timing of decomposition of cereal rye residue N that is recovered in the soil.



This diagram describes the overall goal of the study to track cereal rye residue N into the soil after termination in the spring, out the soil and into the corn plant after planting to corn harvest. The diagram is centered on corn but do note that the project involved both corn and soybean.

Protocol:

1. The study was conducted at the Purdue Agronomy Center for Research and Education, near West Lafayette, IN and from a similar site at the Illinois State University Research and Education Farm near, Lexington, IL.
2. A randomized complete block design was established, consisting of six macro plots: cereal rye grown before corn and cereal rye grown before soybean, replicated 3 times.
3. Cereal rye residue N with a high amount of ^{15}N was grown in the micro plot “High Label Nursery.” Cereal rye residue N with a low amount of ^{15}N was grown in the “Low Label Nursery” micro plot.
4. Corn and soybean samples were sampled at an early vegetative growth stage, early reproductive stage and physiological maturity.
5. Soil samples were collected at corn and soybean planting and each tissue sampling date.
6. Results presented here are averaged across two site-years.

A: Application of enriched NH_4Cl to the nursery plots. **B:** Process of harvesting and placing the residue from the nursery plots into micro plots. **C:** Red lines indicating placement of future corn and soybean rows. **D:** Metal strips installed around the perimeter of micro plots to prevent residue movement.

Results/Discussion:

Objective 1: Recovery of Cereal Rye Residue Nitrogen in Corn and Soybean

Recovery of cereal rye residue N in both corn and soybean increased across the growing season. At the V6, Vt-R1, and harvest the corn crop recovered 2.7%, 7.7%, and 10.4% of cereal rye biomass N. Similarly, at V6, R1, and harvest the soybean crop recovered 1.7%, 6.0%, and 9.8% of cereal rye residue N (Figure 1). At harvest, we found an average of 10.1% (1.8 lbs/A) of cereal rye residue N was utilized by the following cash crop (corn or soybean). Corn recovered 8.2% and 2.2% of cereal rye reside N in the grain and stover, respectively and the soybean crop recovered 7.4% and 2.4% of the grain and stover, respectively. As a result, 2.3% of cereal rye residue N in the stover is returned to the soil for potential use by future crops. While an average of 7.8% of cereal rye residue N was removed from the system at grain harvest (Figure 2).

Objective 2: Recovery of Cereal Rye Residue Nitrogen at the Agronomic Soil Depth

Recovery of cereal rye residue N in the 1-foot soil depth increased over time ranging from 18.3% (planting) to 44.0 % (harvest) (Figure 3). The rate or cereal rye decomposition peaked before planting, then slowed as the growing season progressed (Figure 4). It is possible that soluble organic-N was flushed out of the cereal rye early in the decomposition process due to precipitation. While less-soluble organic-N was decomposed at a slower rate after corn and soybean planting.

Weather conditions for both site years were normal for the region, relative to the 30 year average, allowing adequate corn and soybean growth. Corn yield ranged from 180 – 200 bu/ac and N uptake between 120 -160 lbs N/ac over the course of the study. Soybean yield ranged from 46 - 71 bu/ac and absorbed 170 - 200 lbs N/ac. In the event of cooler or wetter conditions, cereal rye residue would have a slower rate of decomposition resulting in less cereal rye residue N available for corn and soybean N uptake, and the opposite would be true for warmer conditions. Recovery of cereal rye residue N in the soil was consistently lower in corn plots compared to soybean plot. One potential explanation for lower recovery in the soil was greater cereal rye residue N uptake in corn tissue relative to soybean. By the end of the season, an average of 44.0% cereal rye residue N was recovered in the soil across both corn and soybean systems, while only an average of 10.1% was utilized by both cash crops. Suggesting that only a small amount of decomposed cereal rye residue N in the soil becomes available for plant uptake during the following growing season. In corn production following cereal adoption, this finding suggest greater management of N fertilizer must be considered in order to recover the available soil N that the cereal rye plant used to grow and returns very slowly. We recommend management such as moving a greater percentage of the total N rate to planting.

Fate of Unrecovered Cereal Rye Residue Nitrogen

On average, 45.9% (7.9 lbs/A) of cereal rye residue N was not utilized by the following cash crop or recovered in the top 1 foot of soil. A greater mass of cereal rye residue N was recovered in soybean system compared to the corn system (Figure 5). There are multiple fates of unrecovered cereal rye residue N in both the corn and soybean systems. First, a portion of cereal rye residue N was likely stored in corn and soybean roots, which were not sampled as part of this experiment. A conservative estimate is that corn root N maybe 20-30% of corn above ground biomass. Thus, this might account for a portion of unrecovered cereal rye residue N. Second, cereal rye residue N may also have been lost from the top foot of soil due to leaching. In both corn and soybean systems we saw evidence of cereal rye residue N movement to lower depths in the soil profile. At each sampling date, an average of 5% of cereal rye residue N was recovered in the lower soil depth (4-12 inches). Suggesting that leaching of cereal rye residue N began soon after cereal rye termination and continued throughout the growing season. Cereal rye residue N might also have been lost to the atmosphere via denitrification. In some situations, cereal rye has been shown to increase soil moisture and increase the rate of soil denitrification. Finally, it is possible for a portion of cereal rye to remain undecomposed and still have the potential to contribute to soil N cycling in the future.

Summary and Implications

- Reducing nitrate leaching through tile-drainage is a valued ecosystem service of adopting cereal rye. This reduction of nitrate leaching is a result of cereal rye residue N uptake and assimilation of N into its plant structure, reducing the vulnerability of N to leaching. In our study, **we found that only 10% of cereal rye residue N is utilized by the cash crop following spring termination.** This finding suggest that cereal rye residue scavenges N and returns is slowing to the following cash crop and thus a N credit should not be taken for corn following cereal rye.

- At cash crop harvest, **we determined that an average of 44.0% cereal rye residue N was recovered in the soil, while only an average of 10.1% was utilized by both cash crops.** Suggesting that the majority of the N recovered in the soil due to decomposition of cereal rye residue resulted in N that was unavailable for plant uptake during the following growing season. This finding demonstrates that although the residue has disappeared from the surface, it does not mean that all the N in the residue is available to the cash crop. A large portion of cereal rye residue N does remain in the soil, where it could contribute to soil organic matter building, N cycling and maybe utilized by a future cash crops.

- In corn production following cereal adoption, data from this study suggests adaptive management of N fertilizer must be considered in order to replenish available soil N that the cereal rye plant used to grow and returns very slowly. We recommend management, such as moving a greater percentage of the total N rate to planting.

- Future research might examine the fate of N release from other cover crop species, such as legumes and brassicas, which may result in greater N utilization by the following cash crop with less changes to conventional N management. Furthermore, there is a need to determine what the environmental trades are with the use of other cover crops other than cereal rye, which is very effective at scavenging N and reducing soil erosion.

Figures

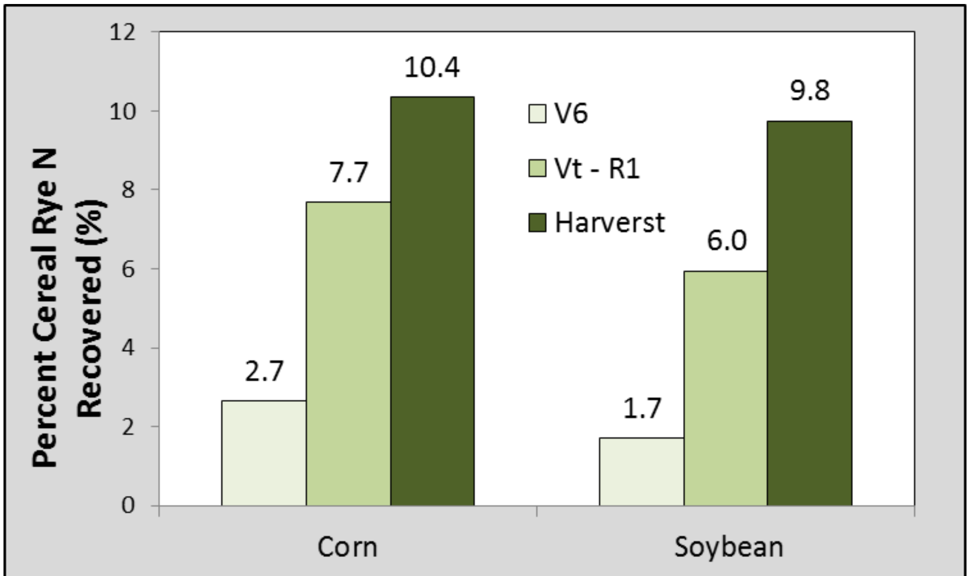


Figure 1. Recovery of Cereal Rye Nitrogen in Corn and Soybean. Recovery values (%) are averaged across both site years, little variability was observed between site years.

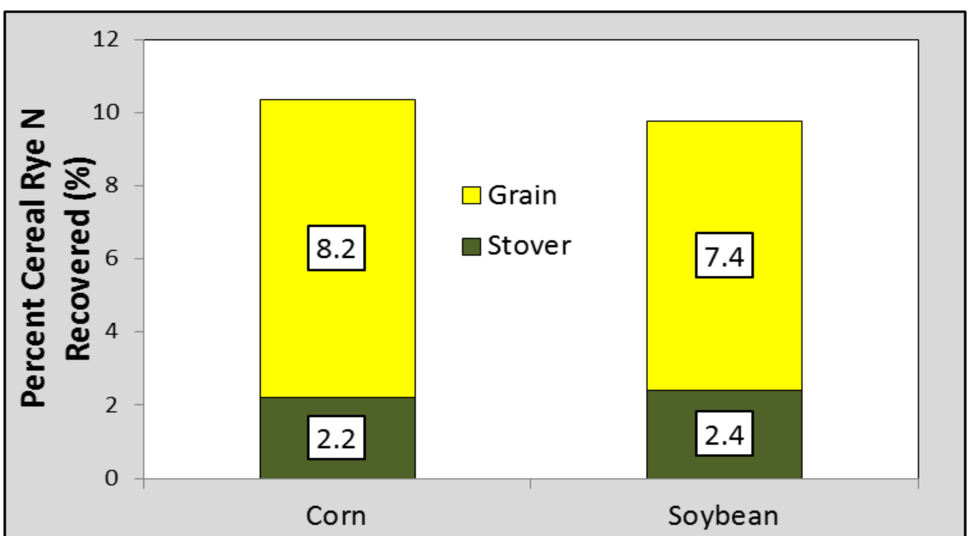


Figure 2. Recovery of Cereal rye residue Nitrogen in Corn and Soybean
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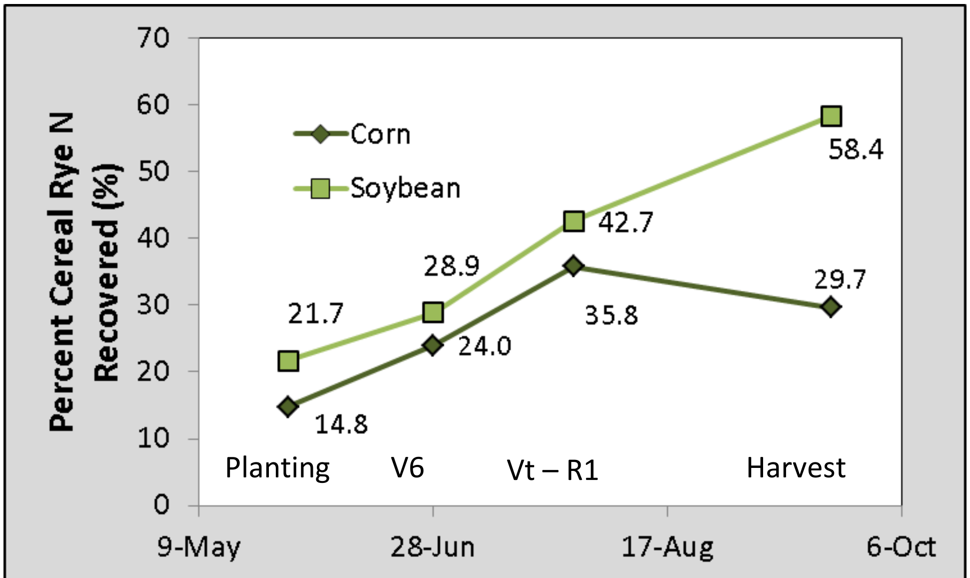

Figure 3. Recovery of Cereal Rye Nitrogen in the top 1-foot of the soil surface following cover crop termination.

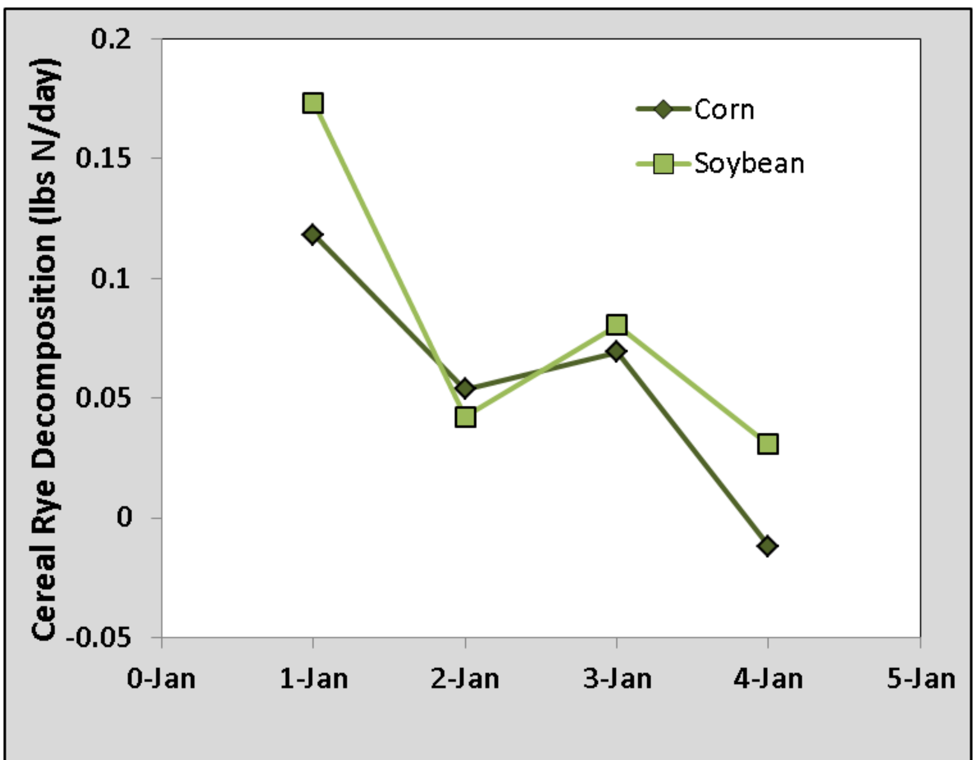

Figure 4. Rate of Cereal Rye Nitrogen recovery in the top 1-foot of the soil surface following cover crop termination.

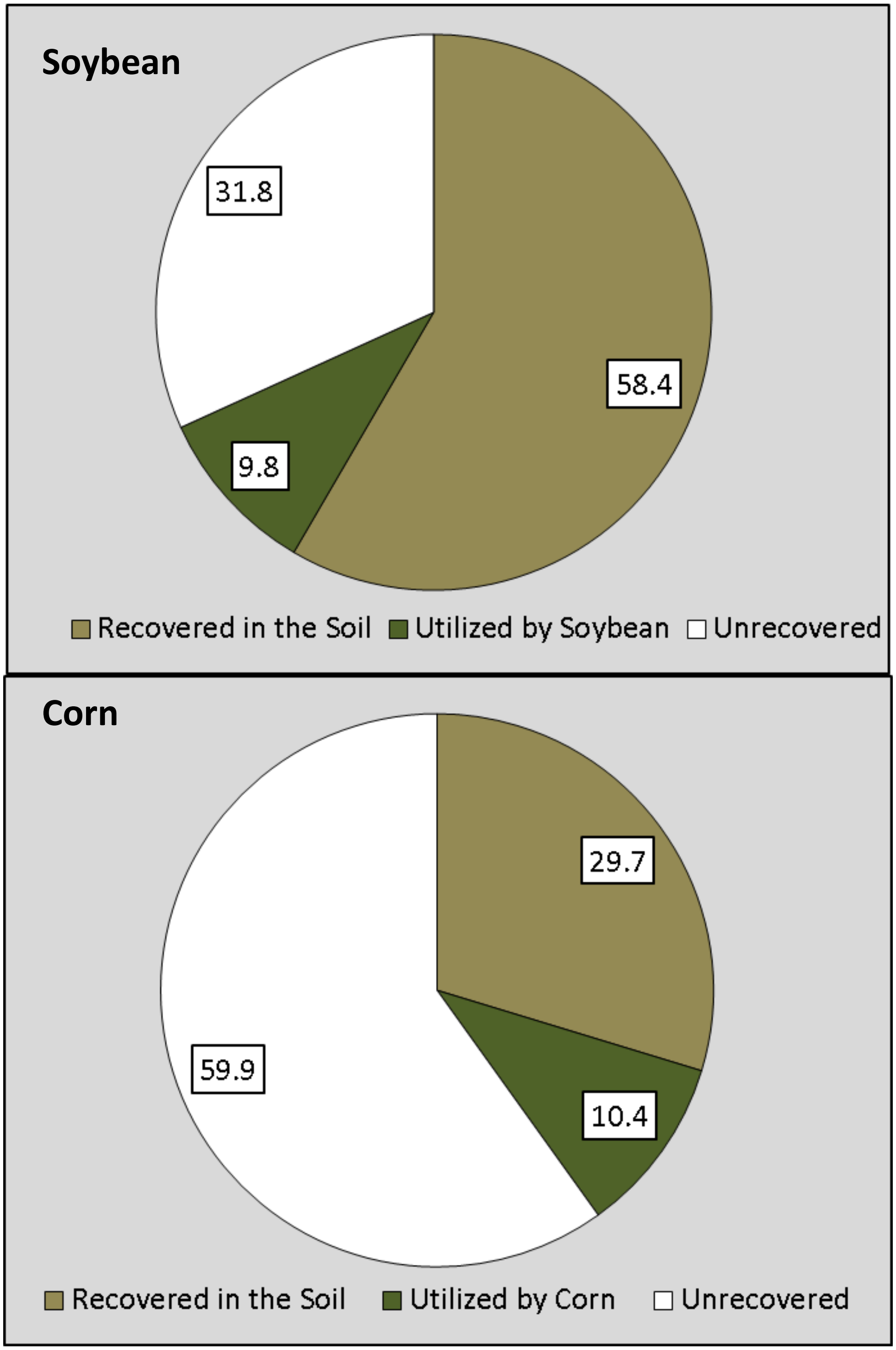

Figure 5. Recovery of cereal rye residue N in both soybean and corn crop years.