Field Validation of Mineral N Cycling from Mixed Crop Residues in Long-term No-till Systems

2022 Progress Report to the North Dakota Soybean Council

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Introduction:

Work by Aher et al. (2016) and Chatterjee et al. (2016) generated questions about the ability of N mineralization from post-harvest crop residues to contribute to the N nutrition of subsequent crops. Recently, we reported results of laboratory work on evaluating N mineralization showing that post-harvest residues have wide C:N ratios that favor N immobilization during decomposition Alghamdi and Cihacek, 2021; Alghamdi et al. 2021; Alghamdi et al., 2022). Recognizing that field conditions may not result in the same research conclusions, we have undertaken a field validation of our results with continuous temperature and moisture monitoring. In addition, our previous research indicated that incorporating narrow C:N crop residues (potentially from cover crop species) may tend to mitigate N immobilization from decomposing post-harvest crop residues. This could potentially reduce the need for higher rates of N fertilizer in long-term no-till cropping systems.

The objectives of this research are (1) to evaluate effects of high rates (15 to 30 % of total residue) of low C:N ratio cover crop (radish) residue on mitigating N immobilization, and (2) evaluation of repeated occurrence of low C:N cover crops in crop rotations on mitigating N immobilization.

Materials and Methods:

Sixty-four plots were instrumented with time domain reflectometer sensors (5TM) to continuously monitor soil moisture and temperature at a depth of 5 cm below the soil surface. The residues were applied on the soil surface (no-till) or mixing the crop residue with the soil using a hand trowel to a 5 cm soil depth (simulated tillage). Seventy five grams of crop residue were applied to each plot to represent 6T of residue per acre (a common level of residue in no-till fields after harvest). Treatments also included a 30 lbs. N/acre fertilizer application on selected microplots to evaluate an N priming potential as an ammonium nitrate solution. Soil samples will be periodically collected with a soil probe tube and analyzed for NO_3-N to evaluate changes in soil N status. The residues were applied either alone or with 15 % or 30 % radish residue by weight. The radish residue was included with the spring wheat and soybean treatments due to these crops being harvested earlier in the season and would be likely candidates for seeding to cover crops after harvest. Radish has a narrow C:N ratio and based on our previous work, releases N quickly upon decomposition. This has the potential to offset N immobilization by decomposing residues. Table 1 shows the residue combinations and sequence of application. All combinations of residues are present each cropping year or simulated cropping year.

Table 1. Crop residue treatments and their rotations for corn (C), soybean (S), spring wheat (SW), radish (R) with 30% incorporation and the bare, unamended soil control alone over three-year study period.

Year/ Cycle	Crop Residue Treatment Rotations						
1st	C	S	SW/R	S/R	C	SW	Control
2nd	SW	C	S/R	C	SW/R	S	Control
3rd	S	SW	C	SW/R	S/R	C	Control

Control – soil without residue added; S – soybean; C – corn; SW – spring wheat; R – radish.

Due to the potential of adverse weather conditions affecting the field plot work, a parallel laboratory study was also established using the methodology of Stanford and Smith (1972). This lab study included the same treatments as the field study. At the writing of this report, two of the three cropping cycles have been completed. The results reported here are based on the laboratory component of this research. The field study is ongoing and the second season of treatments was established in late may of 2022. Temperature and moisture data from the first (2021) season is currently being summarized and analyzed.

Results and Discussion:

Figure 1 shows the average N mineralization of the crop residue combinations with 15 % or 30 % radish residue incubated with the residue on the soil surface (no-till) or mixed with the soil (tilled). Figures 1a and 1c had the residues mixed with the soil while Figures 1 and 1d had the residue placed on the soil surface. These figures represent the N mineralization in each treatment based on the first residue in the crop sequence in the figure legends.

Residue containing 15 % radish mixed in the soil showed N immobilization across the time period representing the active crop growth period of the growing season while the residue on the surface resulted in less N immobilized. Across all the treatments, N mineralization generally occurred around 98 days of incubation which would represent late season N availability when the crop is at or near maturity and its N needs would be low. The 30 % radish treatment showed slightly less immobilization and higher variability in N mineralization/immobilization across the incubation period. The treatments that most prominently show N mineralization late in the incubation period (simulated growing season) are underlined in red in the legends of each figure.

Figure 2 shows the average N mineralization during the second incubation period (simulated second growing season). Surface applied residue (no-till) with 15 % radish uniformly showed immobilization across the incubation period (Figure 2b). The second season illustrates that there may be a positive effect on N mineralization where a low C:N cover crop (radish) can

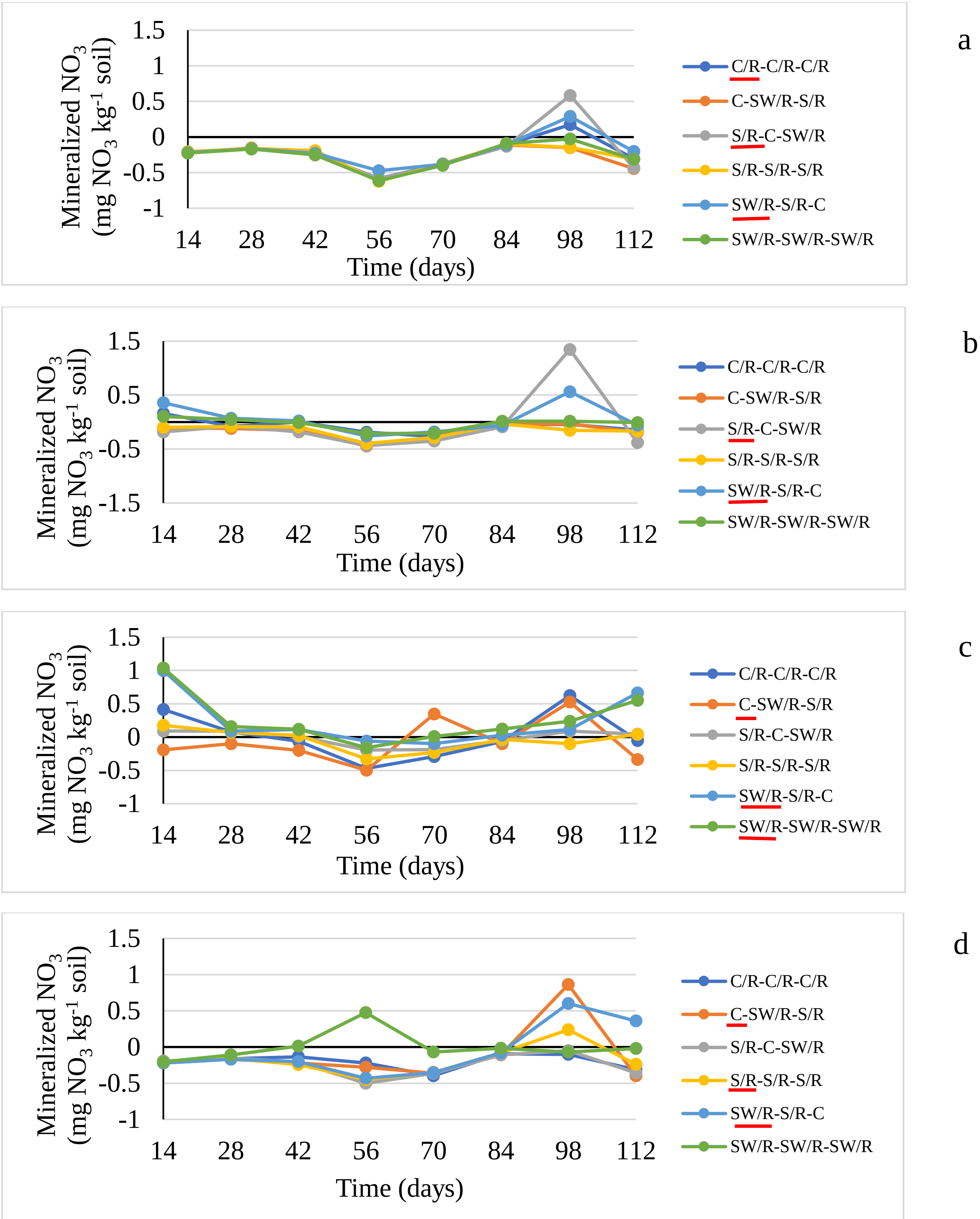

Figure 1. First simulated cropping system season with a rotation of three crops and 15 or 30 % radish residue as part of total residue applied. (a) 15 % radish residue, mixed with soil; (b) 15 % radish residue, residue on soil surface; (c) 30% radish residue, mixed with soil; (d) 30 % radish residue, residue on soil surface. The horizontal line represents N mineralized by soil alone without residue treatment.

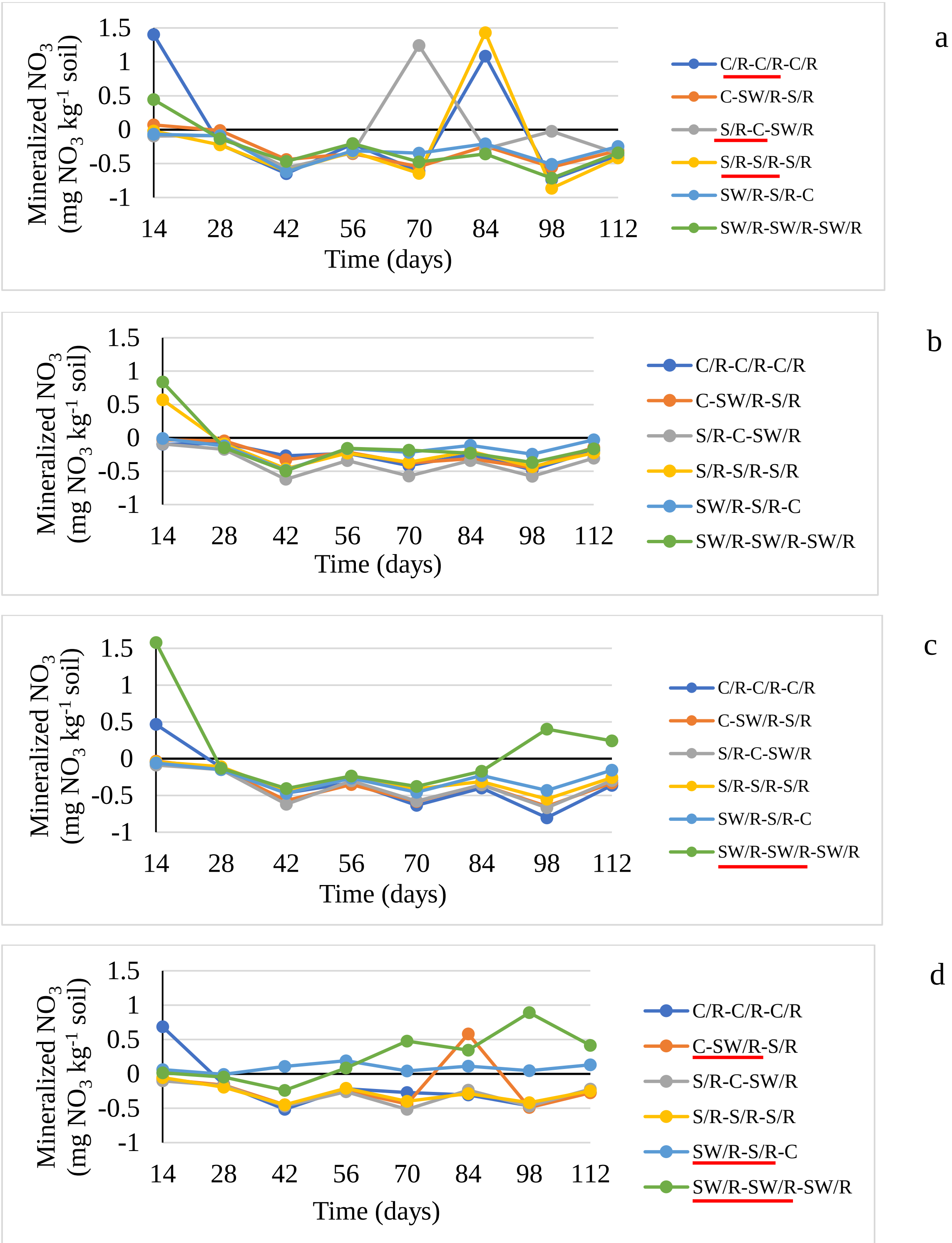

Figure 2. Second simulated cropping system season with a rotation of three crops and 15 or 30 % radish residue as part of total residue applied. (a) 15 % radish residue, mixed with soil; (b) 15 % radish residue, residue on soil surface; (c) 30% radish residue, mixed with soil; (d) 30 % radish residue, residue on soil surface. The horizontal line represents N mineralized by soil alone without residue treatment.

be incorporated with a soybean or spring wheat crop in subsequent years. We are looking at this relationship in the field environment where environmental conditions (temperature and moisture) are highly variable across a growing season. The 2021 season was hot and dry while the 2022 season has started out cool and wet.

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