MID- TO LATE-SEASON N MINERALIZATION POTENTIAL OF NORTHWEST MINNESOTA AND NORTH DAKOTA SOILS

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Introduction:

Optimization of nitrogen (N) fertility for sugar beet production is critical for maximizing relative sugar yields, yet establishing the economically optimum N application rate is challenging. In-season mineralization of organic nitrogen affects sugar yield and N fertilizer requirements of sugar beets. Variability in soil conditions both within and across sites limits our ability to accurately predict N mineralization potential. Weather conditions, soil moisture, soil characteristics, and crop residue can all affect N mineralization rates in corn and soybeans (Fernandez et al., 2017). However, available knowledge on how these processes might affect N mineralization in sugar beets is limited.

Previous studies in sugar beets have evaluated whether the previous crop and crop residues may affect N mineralization rates and/or recoverable sugar. Moraghan et al. (2003) found that while mature wheat straw decreased relative sugar yields (RSY) by using up available N during decomposition, volunteer wheat residue increased RSY. Sims (2007) found that N mineralization rates were similar following either wheat or soybeans but were lower when following corn. Similarly, Chatterjee et al. (2019) found that sugar beets following corn required up to 100 lb/ac of additional N to account for residue decomposition when compared to sugar beets following spring wheat.

Objectives:

To improve our understanding of the site-specific characteristics that affect mineralization potential, we pursued the following objectives:

1. Estimate the quantity of N mineralized in sugar beet plots during the growing season
2. Determine if N mineralized is affected by site-specific factors such as subsurface drainage, soil texture, or tillage system

Materials and Methods:

This experiment was conducted across various sugar beet plots at the Northwest Research & Outreach Center in Crookston, MN in 2025. We monitored N mineralization in sugarbeet plots for two soil textures (loam and silty clay), two drainage conditions (drained and undrained), two tillage systems (strip-till and conventional till), and two cover crop conditions (fall rye and no cover crop) (table 1). Wheat preceded sugarbeets in each test plot area.

Table 1. Site characteristics of sugarbeet plots used in mineralization sampling in 2025

Site	Soil	Drainage	Tillage	Cover Crop	n	Planting Date	Harvest Date	Mineralization Start	Mineralization End	Incubation Periods
D1	Loam	No tile	Conventional	No Cover	6	5/29/25	9/17/25	5/14/25	7/21/25	9
D2	Loam	No tile	Conventional	Fall Rye	6	5/29/25	9/17/25	5/14/25	7/21/25	9
D3	Loam	No tile	Strip-till	No Cover	6	5/29/25	9/17/25	5/14/25	7/21/25	9
D4	Loam	No tile	Strip-till	Fall Rye	6	5/29/25	9/17/25	5/14/25	7/21/25	9
E1	Silty clay	Tile	Conventional	No Cover	9	5/29/25	9/25/25	5/5/25	7/21/25	11
E2	Silty clay	No tile	Conventional	No Cover	1	5/29/25	9/25/25	5/5/25	7/21/25	11

We used an in-situ incubation method to evaluate nitrogen mineralization potential under different soil and management conditions throughout the growing season (Raison, 1987; Fernandez et al., 2017). In-situ incubation cores were replaced approximately every two weeks during the growing season (May to September). Each time incubation cores were replaced we collected soil moisture and soil temperature within 6 inches of the ground surface.

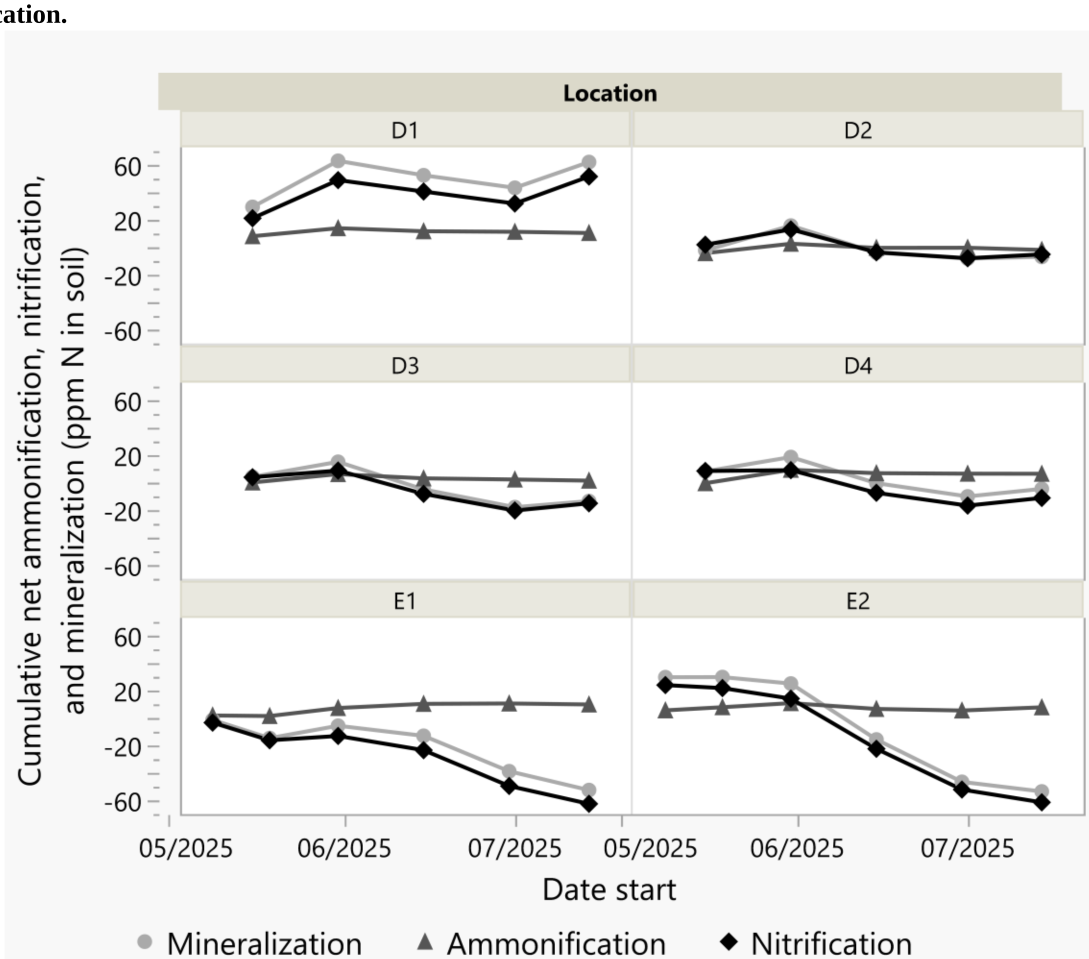
Soils from the incubation cores were air-dried and ground prior to analysis. Soils were extracted with KCl solution followed by analysis on a SEAL discrete analyzer to determine inorganic N content (ammonium- and nitrate-N). Net ammonification and net nitrification were calculated by subtracting post-incubation ammonium- and nitrate-N from initial values for each incubation period. Cumulative net mineralization was calculated by summing net mineralization from each incubation period.

Differences in cumulative mineralization across plots were evaluated using a multiple linear regression approach. The response variable "cumulative mineralization" was approximately normally distributed. The main factors "soil type," "tillage," "drainage," and "cover crop," were evaluated for collinearity using variance inflation factor (VIF) testing. None of the main factor terms were collinear with VIF < 10. Statistical analyses were carried out in JMP Student Edition 18.2.2 (JMP Statistical Discovery, 2025). Initial selection of model terms was conducted using a forward selection procedure with the minimum Corrected Akaike's Information Criterion (AICc) to define the "optimal" model (Akaike, 1974; Burnham and Anderson, 2004) using Stepwise Fit within the Fit Model Platform in JMP. This procedure systematically evaluated factors for inclusion in the model and was used to improve the model's goodness of fit while adjusting for increased model complexity to reduce the probability of overfitting the model.

Results and Discussion:

Cumulative net ammonification, nitrification, and mineralization in May, June, and July varied by location (figure 1). In most plot locations, N accumulated throughout the growing season, but N cycling was not always accumulating. This indicates that both immobilization and mobilization processes were happening during the growing season.

Figure 1: Cumulative net ammonification, nitrification, and mineralization collected within each field location in Crookston, MN during the early 2025 growing season. Mineralization is the sum of ammonification and nitrification.



One three main factors were significantly associated with mineralization from May to July during the 2025 growing season: tillage, soil type, and rye cover crop. Drainage was not a significant factor during this period. Cumulative net mineralization was lower for strip-till plots than conventionally tilled plots, for rye plots than no cover, and for silty clay soils than loam soils. This means that overall, more inorganic nitrogen was immobilized in these plots compared to the other soil treatments (Raison et al., 1987). Lower cumulative mineralization in strip-till and cover crop plots plots may have been slowed due to retention of crop residue (wheat stubble from the 2023 growing season) on the ground surface during the early part of the growing season (e.g., Raison et al., 1987; Salahin et al., 2010). This result is in line with the findings of previous work on sugarbeets and suggests that strip-tillage may require some adjustments in N crediting to account for decreased carbon in the root zone (Moraghan et al., 2003; Lamb et al. 2009). Further data analysis will link full growing season mineralization data to sugarbeet yield and quality data for the 2025 growing season. Additional research is needed to determine the impact of nitrogen cycling and its timing on sugarbeet yield.

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