Tile Drainage of Agricultural Land and its Impact on Nitrogen Mineralization

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Introduction

Nitrogen (N) represents a major input cost for farmers in Minnesota.

Mineralization can provide substantial amounts of N to growing crops, but quantification of when and how much N is produced in agricultural fields is lacking.

Objectives

To determine *in situ* N mineralization in corn (*Zea mays* L.) and soybean (*Glycine max* L. Merr.) in a corn-soybean rotation under different N and soil drainage management.

Materials and Methods

- A multi-year study was established near Wells, Minnesota in a Marna silty clay loam and Nicollet silty clay loam soil.
- This study includes data from the 2014 and 2015 growing seasons.
- Tile drainage was installed in 2011 in all plots but since installation some have been open and others closed to create drainage treatments (Drained and Undrained).
- Crops evaluated were Corn and Soybean in both growing season.
- N management: Control (0N), and Fertilized with pre-plant N application of 135 kg N ha^{-1} (135N) for corn and 45 kg N ha^{-1} (45N) for soybean as urea-N (46-0-0) broadcast and incorporated by shallow (5 cm) tillage.
- Volumetric water content and soil temperature was measured at 0-5, 5-10, and 10-15 cm depth increments during both growing season.
- An *in situ* sequential capped-core sampling technique was used to measure net ammonification, net nitrification and net N mineralization, measured as the difference between final and initial concentrations of NH_4^+-N, NO_3^--N, and total inorganic N (NH_4^+-N + NO_3^--N) for each incubation period in the top 15 cm of soil. This process was repeated approximately every 14 days until the end of the growing season. Soil moisture difference in the incubation tube vs. surrounding soil was <5%.
- Corn and soybean grain yield was measured at harvest.
- Statistical analysis was conducted using the PROC GLIMMIX procedure of SAS considering year, drainage systems, crop and N management as fixed effects and block as random effect.

Results and Discussion

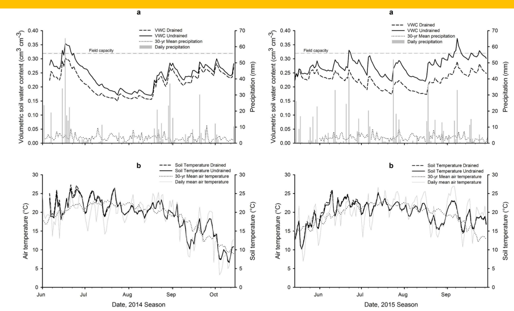

Figure 1. Daily and 30yr-normal precipitation (a), daily and 30-yr normal air temperature (b), and volumetric soil water content (a) and soil temperature (b) at 0-15 cm depth in drained and undrained conditions for 2014 and 2015 growing seasons.

- Precipitation largely influenced soil VWC (Fig. 1).
- Undrained soils had 12% and 22% greater VWC than drained soils in 2014 and 2015, respectively.
- Soil temperature was not affected by drainage or crop variables.

Table 1. Starting total organic C (TOC) and total N (TN) at 0-15 cm depth.

Variable	TOC	TN
	Mg C ha^{-1}	Mg N ha^{-1}
Drained	34.7 b†	2.43 b
Undrained	41.3 a	2.86 a
Soybean‡	38.3 a	2.73 a
Corn	37.6 a	2.56 a

†Within variable groups, different letters indicates significant differences at P<0.05

‡Crop variable was based on the crop planted in 2014 growing season.

- At 0-15 cm depth, in the undrained soils TOC and TN were 19% and 18% greater than drained soils, respectively (Table 1).
- No significant differences were observed in TOC and TN due to crop variable.

Table 2. Cumulative net mineralized N by the end of each growing seasons as affected by year, soil drainage, crop, and N application.

Variable	Corn		Soybean	
	2014	2015	2014	2015
	.... kg N ha^{-1}...........			
Control-D	11.3	16.9	3.0	17.6
Control-UD	25.4	62.3	13.3	33.0
Fertilized-D	86.0	134.0	19.1	34.3
Fertilized-UD	279.3	-4.3	76.2	1.73
	......................P>F....................			
Year(Y) x Drainage(D)†	0.0695			
Crop	0.0523			
Nitrogen (N)	0.0376			
Y x N	0.0792			
Y x D x N	0.0321			

†Only significant effects and interactions *P* values are presented

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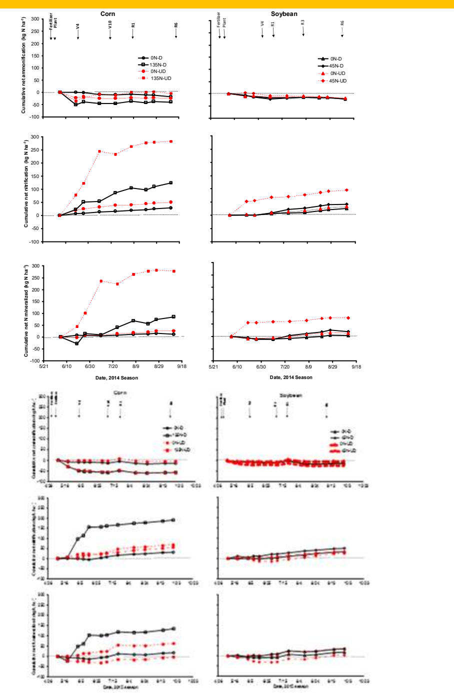

Figure 2. Cumulative net ammonification, nitrification and mineralized N at 0-15 cm depth in 2014 and 2015 growing season.

- Ammonification was likely a short step in the process of mineralization as N was quickly nitrified (Fig. 2). Nitrate was the main form of inorganic N.
- Cumulative net mineralization was positive for all variables in both years, except for 135N in undrained corn in 2015 (Fig. 2).
- Cumulative net mineralized N was greater for corn (76.4 kg N ha^{-1}) than for soybean (24.8 kg N ha^{-1}) showing the influences of previous crop residue on N mineralization.
- A significant Y x D x N interaction showed that cumulative net mineralized N increase from 2014 to 2015 for all treatments except for fertilized undrained soils that decrease (178 kg N ha^{-1} in 2014 and -1.3 kg N ha^{-1} in 2015) indicating that N losses occurred in the system in 2015 (Table 2).
- In corn, N mineralized from the soil TN ranged from 0.53% to 4.16% in drained soils and 1.66% to 5.20% in undrained soils, for 0N and 135N respectively. In soybean, N mineralized from TN ranged from 0.39% to 1.01% in drained soils and 0.88% to 1.47% in undrained soils , for 0N and 45N respectively.
- When N was applied, variability in net mineralization increased and the effect of drainage on mineralization was not consistent across years.