

Changes in Soil Nitrate and Ammonium During the Corn Growing Season as Affected by Nitrification Inhibitors

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Summary

Nitrification inhibitors (NI) are used to delay the nitrification process, increasing nitrogen fertilization efficiency. The objective of this study was to evaluate the effect of NI on soil nitrate ($\text{NO}_3\text{-N}$) and ammonium ($\text{NH}_4\text{-N}$) content throughout the growing season for corn. The study was conducted at four locations (Manhattan, Scandia, Rossville, and Ashland, KS) during the 2017 and 2018 crop seasons. Most of the NI effects on soil $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ were observed early in the season and when the higher nitrogen (N) fertilizer rate was used. An increase in $\text{NO}_3\text{-N}$ soil content was observed during the season with a posterior decrease at the end. At the V8 corn growth stage, we observed the peak of $\text{NO}_3\text{-N}$ soil content at 0- to 12-in. sampling depth with an additional increase at 12- to 24-in. depth in the treatment without NI, suggesting $\text{NO}_3\text{-N}$ movement to the lower soil layer or uptake by the corn crop.

Introduction

Nitrogen is an essential element for optimum corn yields. After applied as fertilizer to the soil, N changes its chemical form and can be subject to potential loss. Nitrification is an important step in the N cycle and is promoted by the biological oxidation of ammonium to nitrite and nitrate. Conversion of $\text{NH}_4^+\text{-N}$ to $\text{NO}_3^-\text{-N}$ increases the potential for nitrogen leaching due to the mobility of nitrate in the soil and can be readily lost from the plant rooting zone (Wiederholt and Johnson, 2005). The nitrification process can occur rapidly in warm, moist, well-aerated soils.

Nitrification inhibitors are chemicals that slow down or delay the nitrification process, thereby decreasing the possibility of large N losses before the fertilizer nitrogen is taken up by plants (Nelson and Huber, 2001). The objective of this study was to evaluate the effect of NI on soil nitrate and ammonium content in the soil throughout the corn growing season.

Procedures

This study was conducted in four locations (Manhattan, Scandia, Rossville, and Ashland, KS) during the 2017 and 2018 crop seasons. Treatments were: 1) N fertilizer without nitrification inhibitor (control), and 2) N fertilizer treated with nitrification inhibitor. Anhydrous ammonia was applied at four rates 0, 100, 150, and 200 lb/a in

early spring. Soil samples were taken at the V2, V4, V8, V12, R1, and R6 corn growth stages at two soil depths (0–12 and 12–24 in.). Soil samples were submitted to the K-State Research and Extension Soil Testing Laboratory on the same day for NO_3^- -N and NH_4^+ -N soil test. The experimental design is in randomized complete blocks with 4 repetitions. Experimental plots were 10-ft wide \times 60-ft long.

Results

Changes in NO_3^- -N and NH_4^+ -N

The form of N in the soil was dependent on soil type (moisture and texture) and climate (temperature and precipitation) characteristics. In general, NH_4^+ -N content in the soil was greater at the initial corn growth stages and decreased during the season. Consequently, NO_3^- -N content increases as a result of the nitrification process (Figure 1).

The use of NI contributed to maintain greater NH_4^+ -N content early in the season in the 0–12 in. depth but no changes in the 12–24 in. depth for any of the corn growth stages (Figure 2). However, the soil NO_3^- -N content was greater for most sampling times in the 0–12 in. depth when the nitrification inhibitor was used. At the 12–24 in. depth, soil NO_3^- -N content showed an increase at the V8 corn growth stage for the treatment without nitrification inhibitor. This increase matches with a peak observed at the same corn growth stage at the 0–12 in. soil layer suggesting a leaching process of NO_3^- -N from the top to the deeper soil layer (Figure 2).

The increase of N fertilizer rates promotes a consequent increase in soil N. However, the NH_4^+ -N fraction was generally low with soil sampling during the growing season, suggesting a low sensitivity of the NH_4^+ -N fraction for soil sampling/testing (Figure 3). On the other hand soil NO_3^- -N concentration was generally greater, and with significant differences with the use of nitrification inhibitor at the 200 lb N/acre rate suggesting a reduction in the nitrification process in the soil at this point in the season (Figure 3).

References

- Nelson, D.W. and D. Huber. 2001. Nitrification inhibitors for corn production. National Corn Handbook. Iowa State University Extension, NCH55.
- Wiederholt, R. and B. Johnson. 2005. Nitrogen behavior in the environment. North Dakota State University Extension Service, Fargo, ND 58103.

Table 1. Levels of significance for soil nitrate (NO₃-N) and ammonia (NH₄-N) affected by treatments, corn growth stages, and soil depth

| Factors | NO ₃ | NH ₄ |
|-------------------|-------------------|-----------------|
| | ----- P > F ----- | |
| Treatment (T) | 0.182 | 0.063 |
| Stage (S) | <0.001 | <0.001 |
| Depth (D) | <0.001 | <0.001 |
| T × S | 0.949 | 0.007 |
| T × D | 0.135 | 0.058 |
| S × D | <0.001 | <0.001 |
| T × S × D | 0.909 | 0.024 |
| | | |
| Treatment | 0.758 | 0.803 |
| Nitrogen (N) rate | <0.001 | 0.012 |
| T × N | 0.329 | 0.005 |

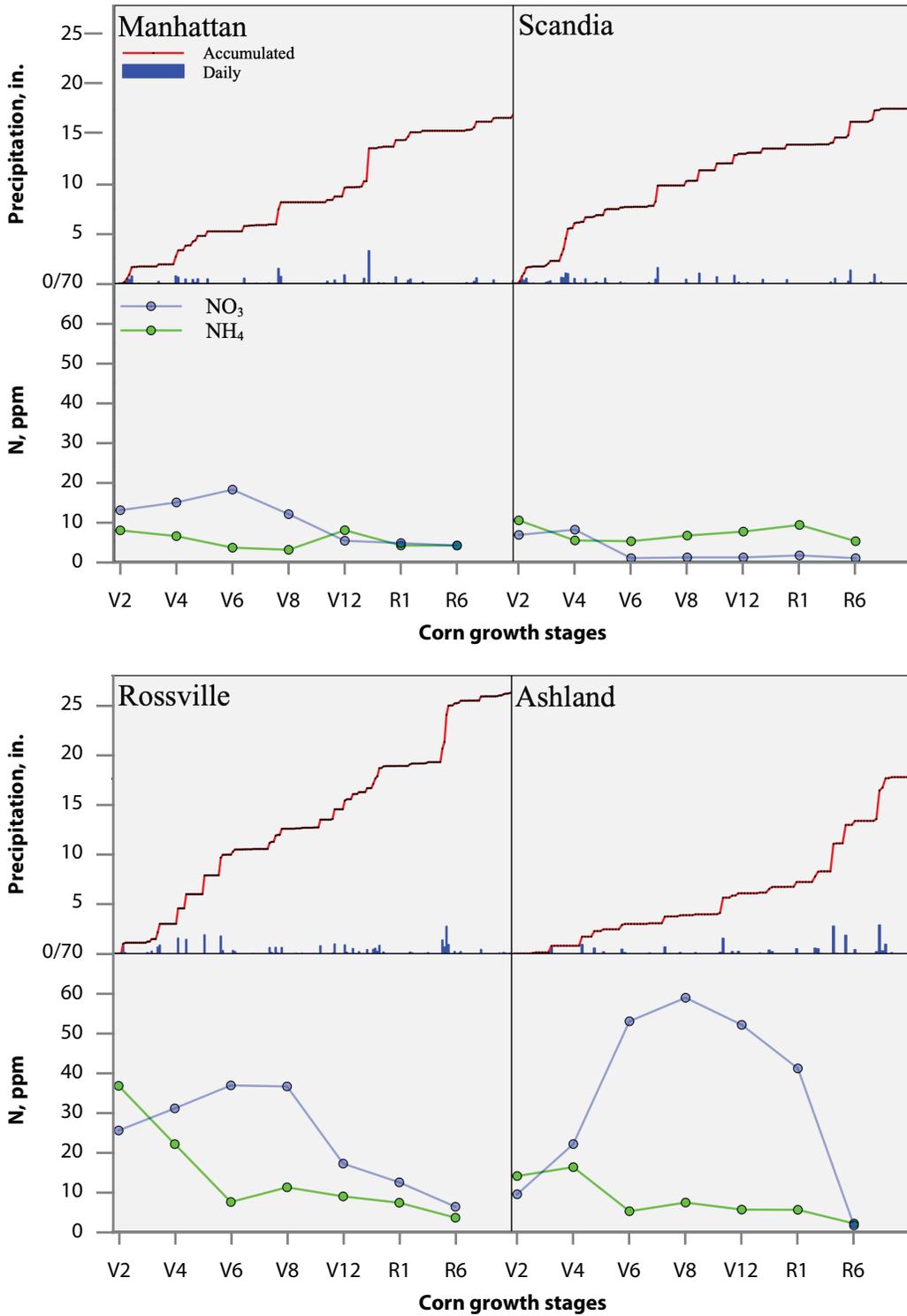


Figure 1. Average soil nitrate (NO₃-N) and ammonia (NH₄-N) content throughout the growing season in Manhattan (2017), Scandia (2017), Rossville (2018), and Ashland (2018), KS, and the respective daily/accumulated precipitation during the study.

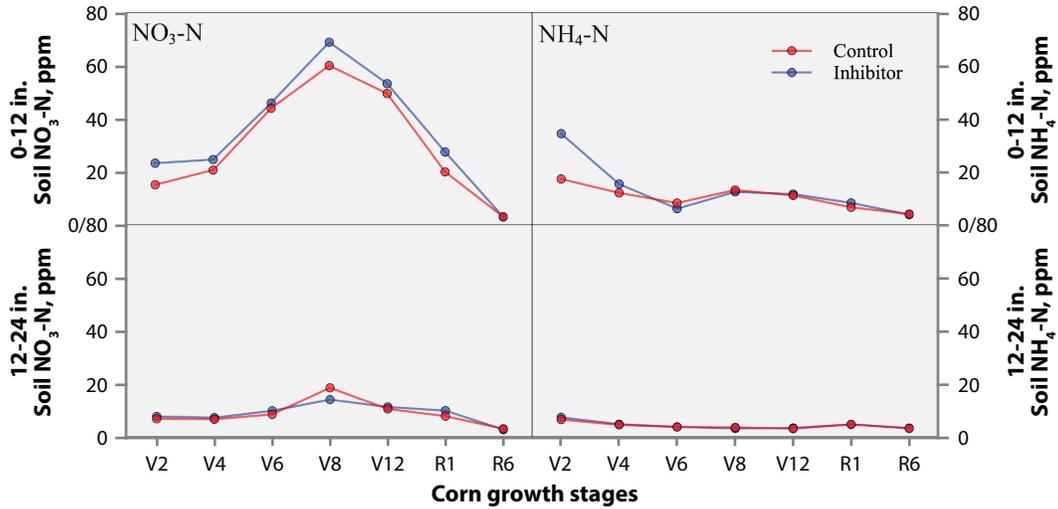


Figure 2. Average soil nitrate (NO₃-N) and ammonium (NH₄-N) content throughout the growing season as affected by the use of nitrification inhibitor in the 0–12 in. and 12–24 in. soil depth. Averaged across locations.

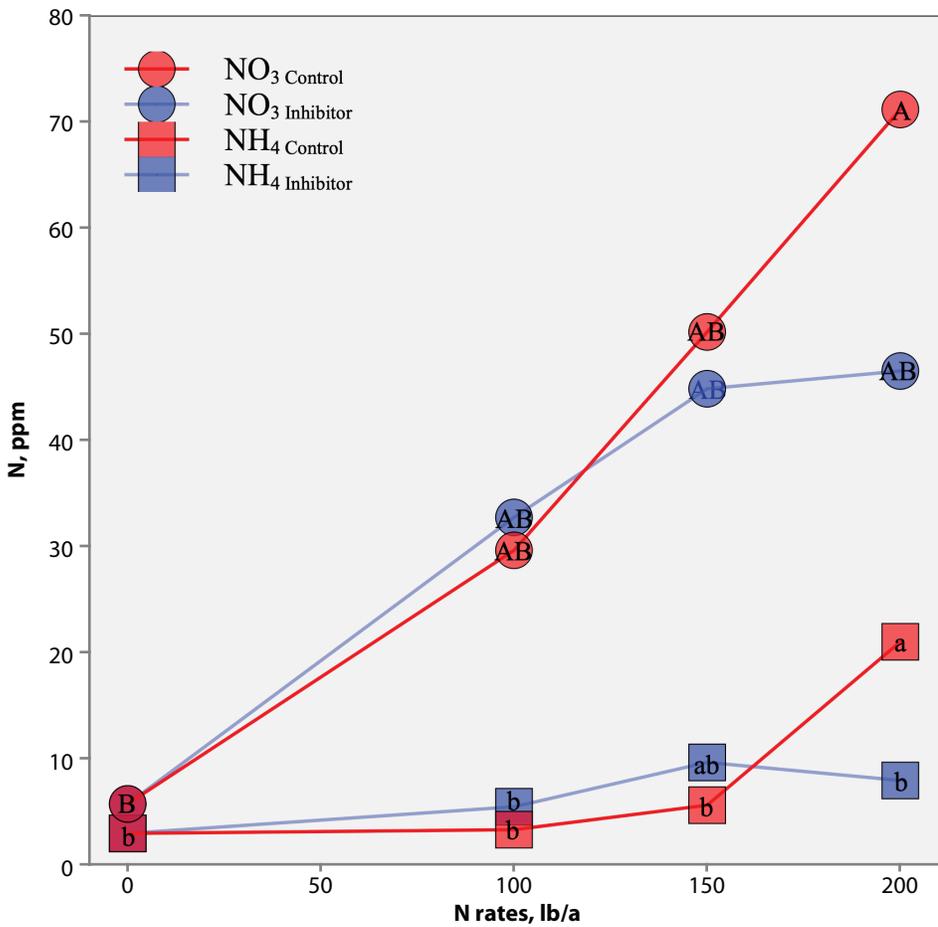


Figure 3. Soil nitrate (NO₃-N) and ammonium (NH₄-N) content as affected by N rates. Samples were collected at the V8 corn growth stage. Uppercase letters are used to compare NO₃-N content in the soil as affected by N rates. Lowercase letters are used to compare NH₄-N content in the soil as affected by N rates.