Use of soil nitrate and ammonium availability to demonstrate the effectiveness of nitrogen fertilizer inhibitors on corn yield

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Introduction

Nitrogen (N) is essential for corn yield production. After N fertilizer is applied in the field, it can be lost to the environment through ammonia volatilization, denitrification, or leaching. Loss of N to the environment can lead to poor air quality and water pollution.

Nitrogen inhibitors are chemical products designed to inhibit specific pathways of the N cycle that could lead to N losses. To test their effectiveness, soil nitrate and ammonium sampling before and after N fertilizer application is done to quantify the impact of N inhibitors in the soil and the crop using an on-farm research set up.

Objectives

- Analyze the dynamics of soil nitrate and ammonium for with and without N fertilizer inhibitor on on-farm research studies.
- Determine the effect of soil type and N application timing on soil nitrate and ammonium dynamics for with and without inhibitors treatments.

Materials and Methods

Experiments were conducted in Nebraska during 2019 (3 sites), 2020 (5 sites), and 2021 (7 sites) (Figure 1. A). Previous crops included soybean, corn and dry edible beans. 9 fields were irrigated and 4 were none irrigated. Tillage practices were no-till, ridge-till, strip-till and turbo-till. Three nitrification inhibitors were tested: pronitradine, nitrapyrin, and dicyandiamide.

Soil samples were collected at 30 cm, 60 cm and 90 cm in 2019 and 2020. In 2021, soil samples were only collected at 30 cm. samples were analyzed every week from when N fertilizer inhibitor was applied for a period of six weeks.

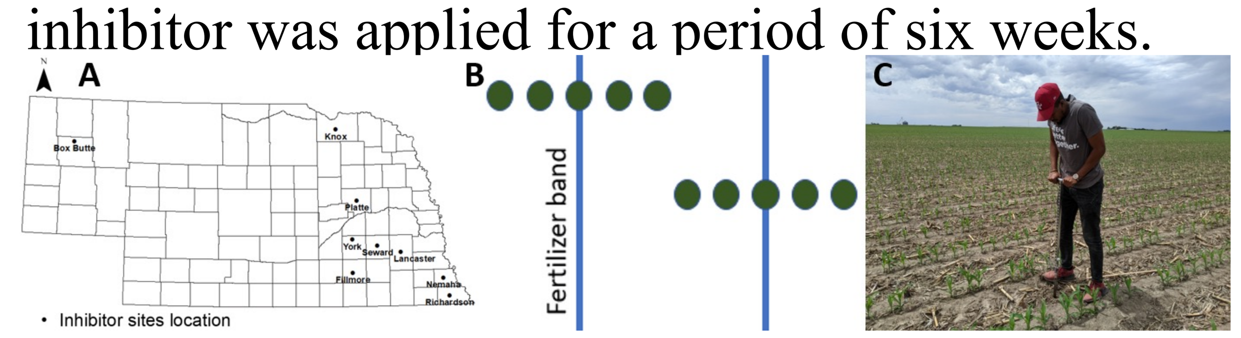

Figure 1. (A) N inhibitor site locations. **(B)** 5 Soil sample cores where 1 core comes from the band, 2 cores come from 25% away from the band and 2 come from 50% away from the band. **(C)** Soil sampling at the on-farm research field in York.

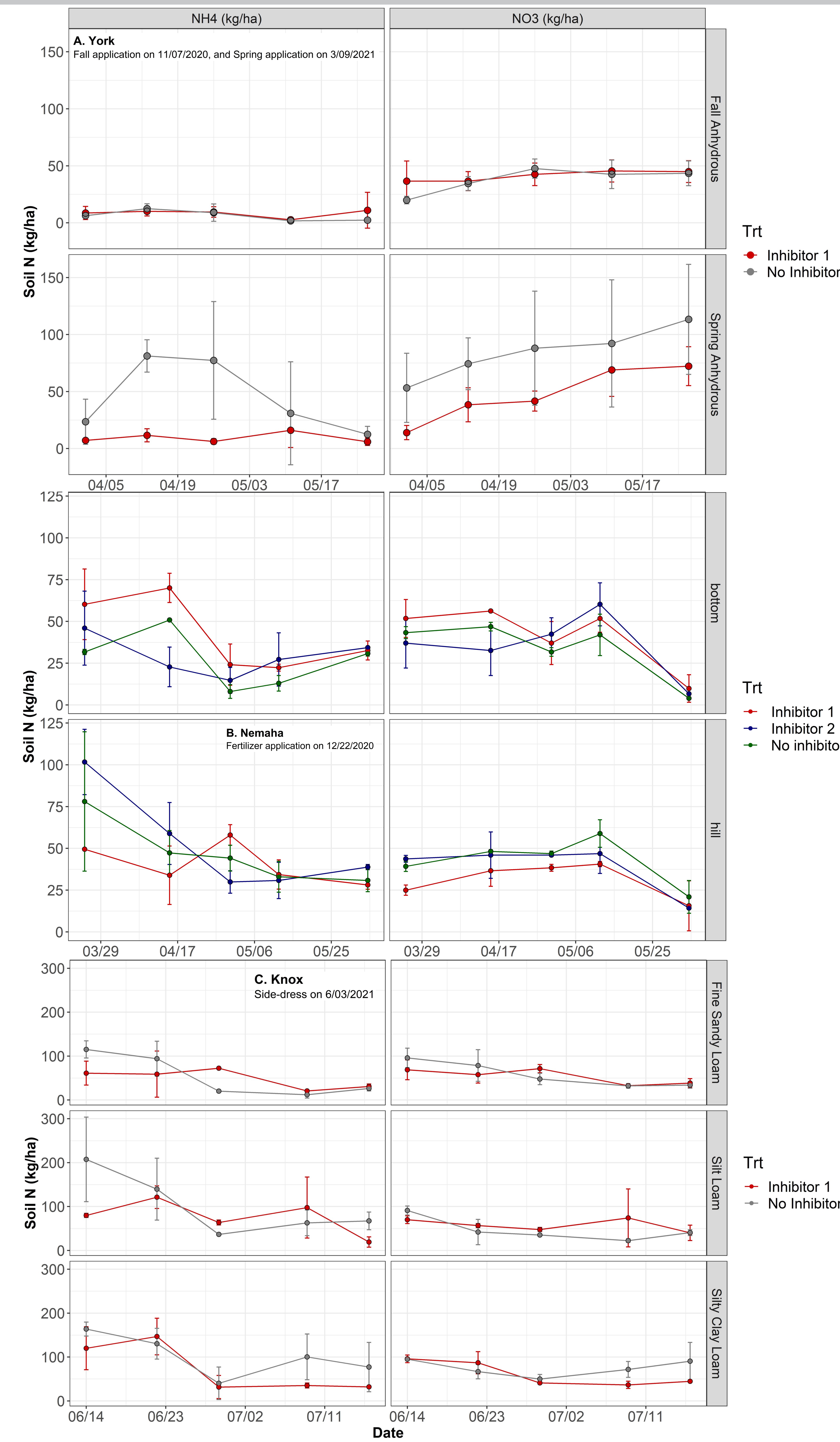

Figure 2. Soil nitrate and ammonium in-season dynamics for three on-farm strip trials with inhibitors and no inhibitor treatments at different (A) application timings, (B) topography areas, and (C) soil types. Vertical lines are error bars representing the standard deviation of the mean.

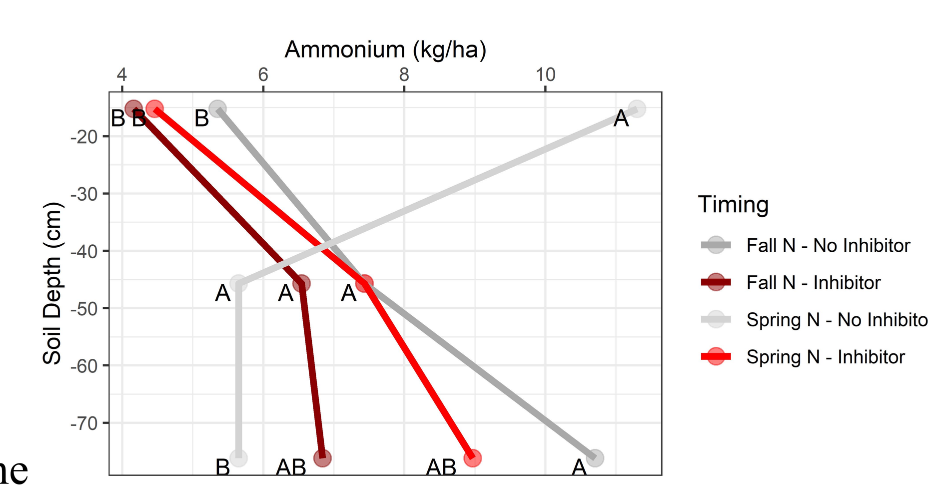

Figure 3. Change of ammonium concentration in kilograms per hectare with response to three soil depth in centimeter for inhibitor and no inhibitor applied at two different times (Fall, and Spring) during the 2020 season. Different letters at the same soil depth indicate statical differences.

Results

Soil test dynamics during the growing season showed no significant trend of higher or lower nitrate and ammonium concentration for inhibitor treatment across all sites (Figure 2). In 2019, ammonium concentration was significantly higher while nitrate concentration was lower in the top foot (9 weeks after application) when nitrapyrin was used at one of the three sites (data not shown). In 2020, there was no significant differences between treatments in the month of May. In June, ammonium concentration was significantly higher for no inhibitor in the top 30 cm for the spring applied fertilizer (Figure 3).

During, 2021 soil results showed no significant differences between with and without inhibitor treatments for soil nitrate and ammonium across (1) application timings ($p > 0.1721$) (Figure 2. A), (2), topographic locations ($p > 0.4554$) (Figure 2. B) and soil types ($p > 0.4554$) (Figure 2. C), .

Conclusions

Soil nitrate and ammonium dynamics were not significantly different between treatment for most of the sites, N application timings, and soil types. Soil dynamics tended to be variable across sites and not following the expected trend. Thus, other soil sampling methodologies and crop metrics are needed to be tested to determine the best methodologies for evaluating inhibitors performance in on-farm research. In addition, further analysis will be performed to determine the response of inhibitors in contrasting zones using yield monitor data and other site-specific characteristics.

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References

Gioacchini, P., Nastri, A., Marzadori, C., Giovannini, C., Vittori Antisari, L., & Gessa, C. (2002). Influence of urease and nitrification inhibitors on N losses from soils fertilized with urea. Biology and fertility of soils, 36(2), 129-135.
Kirschke, Tobias, Oliver Spott, & Doris Vetterlein. (2019). Impact of Urease and Nitrification Inhibitor on NH4+ and NO3− Dynamic in Soil after Urea Spring Application Under Field Conditions Evaluated by Soil Extraction and Soil Solution Sampling. Journal ofPplant Nutrition and Soil Science 182(3), 441–450.
Lassaletta, L., Billen, G., Grizzetti, B., Anglade, J., & Garnier, J. (2014). 50 year trends in nitrogen use efficiency of world cropping systems: the relationship between yield and nitrogen input to cropland. Environmental Research Letters, 9(10), 105011.
Menelas, B. (2014). Nitrogen fertilizer and nitrification inhibitor impacts on soil N dynamics.
Stevens, C. J. (2019). Nitrogen in the environment. Science, 363(6427), 578-580.