Lack of Nitrite and Reduced Nitrate Formation in Side-Banded Urea Treated with the Nitrification Inhibitor Nitrapyrin Linked to Decreased N_2O Emissions

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INTRODUCTION

- Some N stabilizers, such as nitrification inhibitors, proved their ability to reduce nitrogen losses from fertilized fields through N_2O emissions and nitrate leaching.
- Banding is improving it even more by bringing the fertilizer closer to roots, and thus increasing nitrogen use efficiency.
- However, there are not many studies exploring the distribution of nitrogen from bands and the comparison of banded fertilizer with and without an inhibitor.

OBJECTIVE

This study aimed to see how banded urea with and without a nitrification inhibitor (NI, nitrapyrin, eNtrench) affects N distribution and transformation in lateral and vertical directions from the band, and N_2O emissions.

METHODS

- **Site**: Ian N. Morrison Research Farm near Carman, MB.
- **Crop**: Corn, 170 bu/ac.
- **N rate**: 125 kg N/ha. **Method of fertilizer application**: side-band **(Fig. 1).**
- **Soil sampling**: Soil samples were collected by a hand sampler using a grid specially developed on a 3D printer located perpendicularly to the band.
  - There were 14 zones 2.5x2.5 cm, and the band* was always located in the zone #5 **(Fig. 2)**. The 15th sample was collected from the between-rows space – off-band *(*for control, "band" is assumed to be a seed row).*
  - Each treatment was replicated 4 times. Soil was sampled 10 times during one month. Total 1800 soil samples.
- **Gas sampling**: Gas was collected from three static-vented chambers (19L x 7W x 10H cm) per plot in 15-30-45 min interval. Chambers were located on-band, off-band and in the middle **(Fig. 3).**

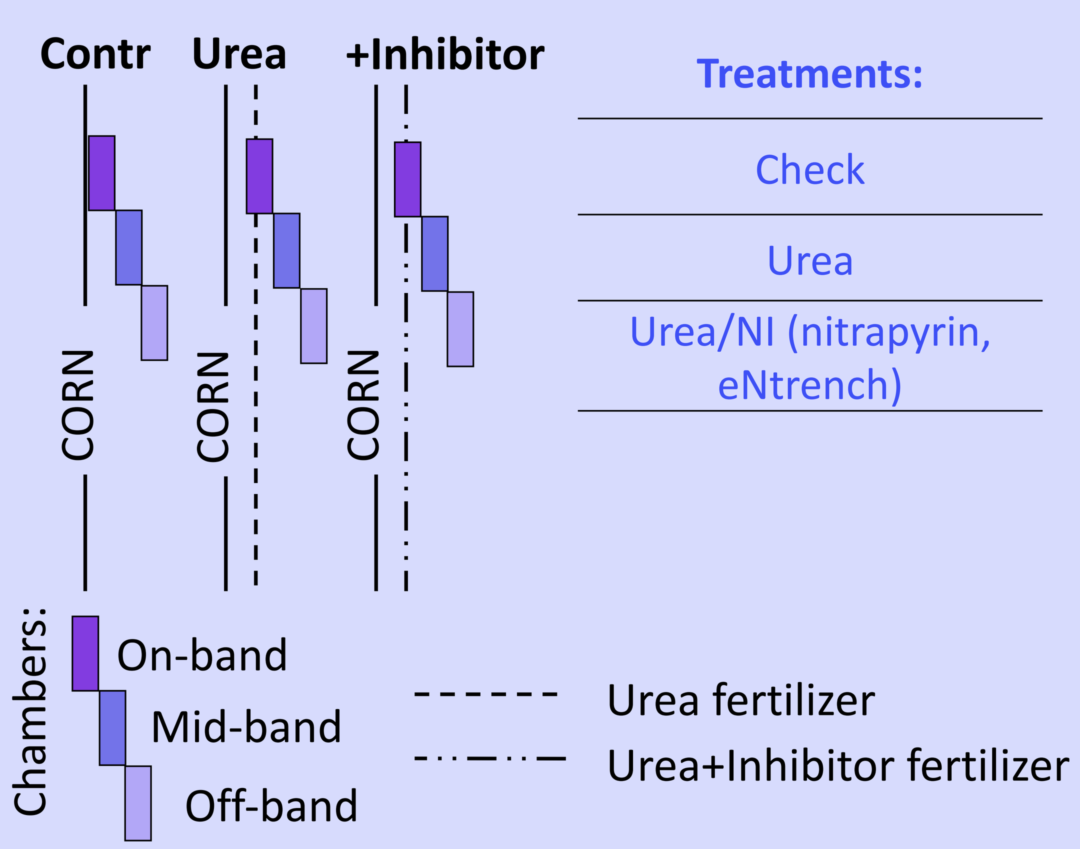

Figure 1. A side-banding scheme on the field

Figure 2. A grid for soil sampling

Figure 3. Static-vented chambers

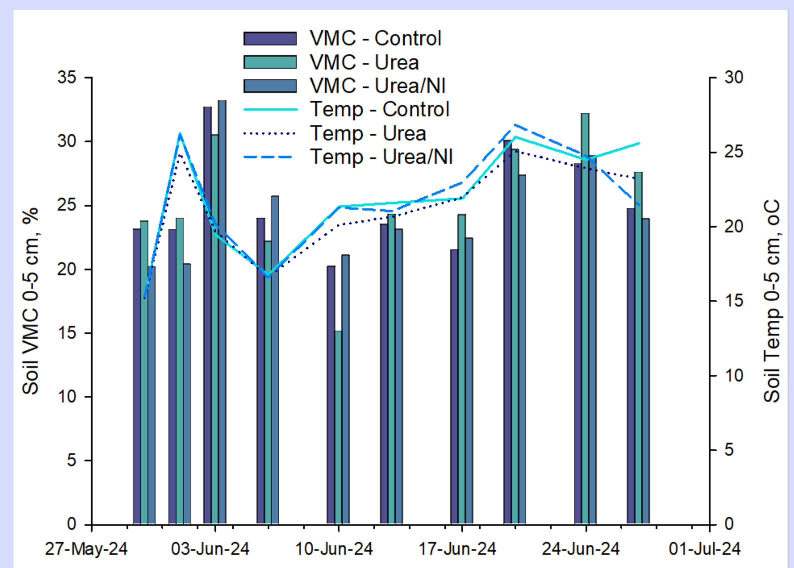

Figure 4. Volumetric soil moisture content (VMC, %) and soil temperature (°C) at 0-5 cm.

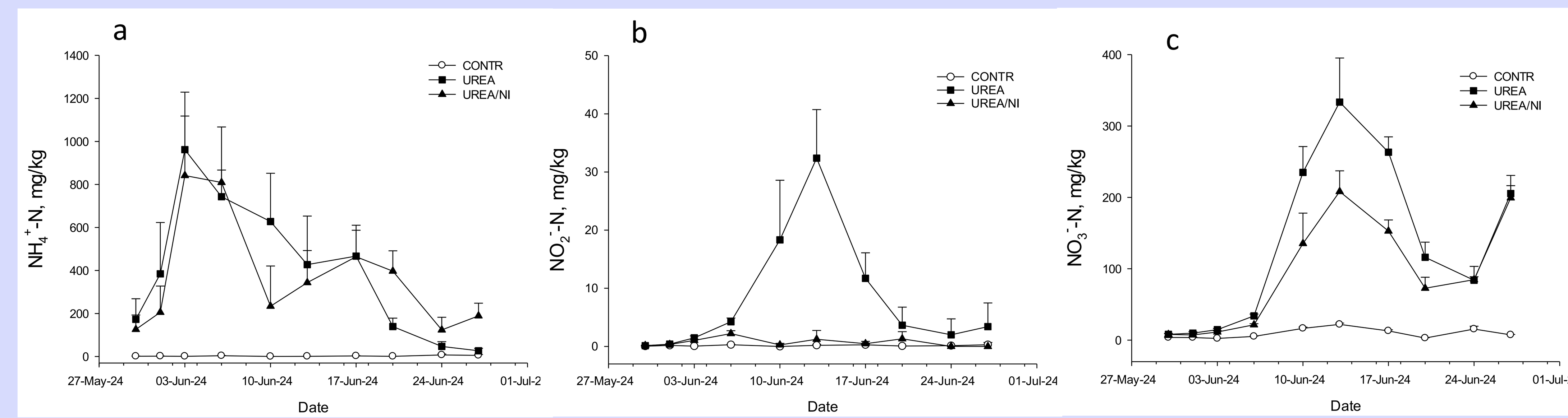

Figure 5. The average NH_4^+-N (a), NO_2^--N (b) and NO_3^--N (c) concentrations (mg N kg^{-1} soil) of the band zone and around it over time in control, urea and urea/NI treatments (error bars represent standard error, n=4).

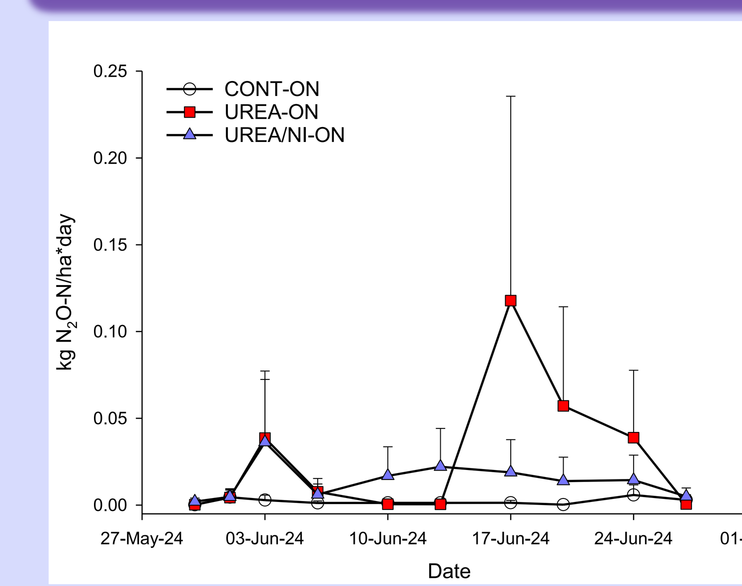

Figure 6. On-band N_2O emissions (kg N2O-N ha^{-1} day^{-1}) from control, urea, and urea/NI treatments (error bars represent standard error, n=4).

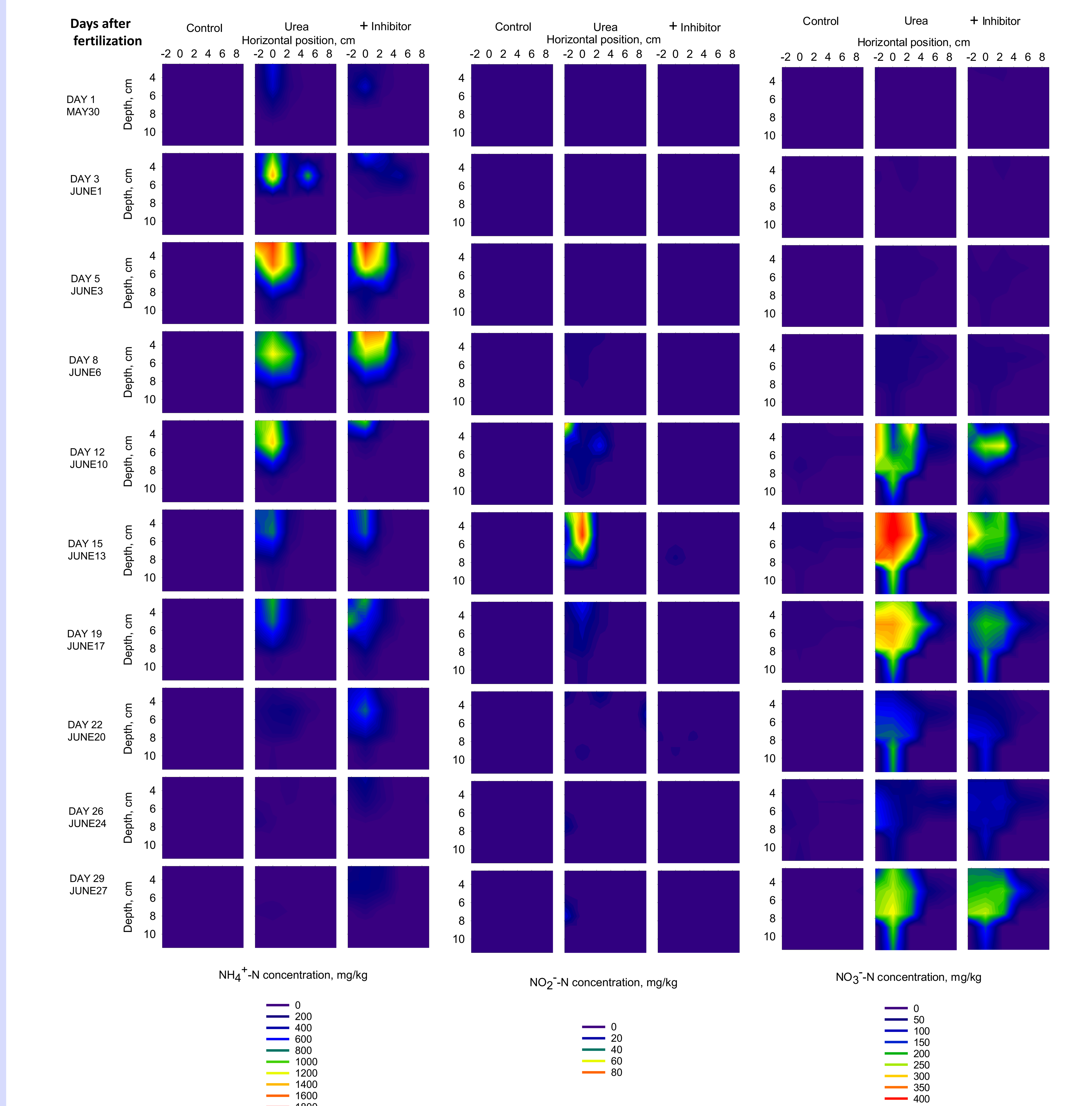

Figure 7. Lateral and vertical distribution of ammonium, nitrite, and nitrate in soil in control, urea, and urea/NI treatments.

RESULTS and DISCUSSION

- Ammonium concentrations remained higher under the NI treatment even three weeks after fertilizer application compared to the urea treatment, indicating that the inhibitor slows ammonium transformation **(Fig. 5a).**
- Nitrites were detected in the urea treatment on days 12 and 15 after fertilization, whereas no nitrites were found in the urea/NI treatment during this period. This suggests that the inhibitor prevents the transformation of ammonium into nitrite and subsequently into nitrate **(Fig. 5b).**
- High nitrate concentrations were observed in the soil on day 12 after fertilization, with levels significantly higher in the urea treatment compared to the urea/NI treatment, further demonstrating the effectiveness of the inhibitor **(Fig. 5c).**

- N_2O emissions **(Fig. 6)** were generally highest on-band, though they were not significantly different from mid- or off-band locations.
- The highest concentration was observed on day 20 in the urea treatment. Interestingly, this correlates with the peak in nitrite concentrations a few days earlier, suggesting that nitrites may play an important role in driving N_2O emissions.

Figure 7 illustrates the lateral and vertical distribution of nitrogen species within the soil profile:

- Ammonium appeared in the soil at concentrations of approximately 200 mg/kg on days 1 and 2 after fertilizer application, reaching a peak concentration of 800–900 mg/kg by day 5, and then gradually decreased both laterally and vertically over the following week. The greatest lateral diffusion was observed on day 5, extending 5–6 cm from the band zone, and 8-9 cm vertically.
- Nitrites were detected in the soil only on days 12 and 15 in the urea treatment, with peak concentrations of 80 mg/kg and limited diffusion of 3–4 cm from the band.
- Nitrates appeared in the soil on day 8, peaking at 400 mg/kg on day 15. Laterally, nitrates were distributed up to 8 cm from the band zone, while vertically, they were still detected 10 cm below the band.

CONCLUSION

- Results showed that Nitrapyrin was effective in reducing nitrogen transformations, contributing to a better understanding of nitrogen distribution in soil.
- Prevented accumulation of nitrite in side-banded urea with nitrapyrin is linked to reduced N_2O emissions.
- Additionally, the findings provide unique insights into the temporal distribution of nitrogen species in soil, which can improve the representation of the nitrogen cycle in biogeochemical models.

ACKNOWLEDGMENTS

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