# LANDSCAPE POSITIONS AND NITRIFICATION INHIBITORS AFFECT CORN PRODUCTIVITY ON CLAYPAN SOILS

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## ABSTRACT

Corn nitrogen (N) management in claypan soils is highly influenced by spatial and temporal variability caused by complex soil and water interaction within a landscape. This study investigated the impact of N application rates and nitrification inhibitors (nitrapyrin and pronitridine) on corn productivity across three topographic positions (shoulder, backslope, and footslope) in claypan soils at the Lee Greenley Jr. Memorial Research Farm, Novelty, Missouri, during 2023 (dry year) and 2024 (wet year). The experimental design was a split-plot design having topographic positions as main factors and N rates (0, 60, 120, 180, and 240 lb N $ac^{-1}$) and nitrification inhibitors (120 and 180 lb N $ac^{-1}$ with nitrapyrin or pronitridine) as split factors. Results showed significant yield differences across topographic positions and years, with higher yields generally observed in 2024 due to higher precipitation during the cropping season. In 2023, 180 lb N $ac^{-1}$ + nitrapyrin produced the highest yield (148 bu $ac^{-1}$) at the footslope, while in 2024, 180 lb N $ac^{-1}$ + nitrapyrin reached 178 bu $ac^{-1}$ at the footslope. Applying nitrification inhibitors at 180 lbs N $ac^{-1}$ at the backslope and footslope topographic positions improved yields compared to N application at 180 N $ac^{-1}$ without nitrification inhibitors in both years. Nitrification inhibitors enhanced corn yield, especially in wet conditions, suggesting reduced N losses through leaching and denitrification. This research highlights the importance of optimizing N management strategies and nitrification inhibitor technology to maximize corn yields in variable soil moisture conditions typical of claypan landscapes. It also reiterates the importance of using site-specific variable source technology on these landscapes.

## INTRODUCTION

Nitrogen (N) management in corn production is challenging due to varying soil conditions, particularly in claypan soils characterized by poor drainage (Nash et al., 2012). Topographic positions significantly affect N dynamics, with higher yields typically observed in well-drained upper slopes and lower yields at footslope due to water accumulation (Halvorson & Doll, 1991; Miao et al., 2006; Singh., 2022). However, lower positions like the footslope can outperform upper slopes during dry years, because of increased moisture retention particularly on claypan soils (Gentry et al., 2009).

Nitrification inhibitors like nitrapyrin and pronitridine can address yield disparity by enhancing N use efficiency and reducing losses across slope positions under varying climatic conditions (Steusloff et al., 2019; Singh et al., 2019). Studies have shown that applying nitrapyrin with anhydrous ammonia on claypan soils can reduce N losses by 20 to 55% and increase corn yields by 10 to 68 bu $ac^{-1}$ under various conditions (Nash et al., 2013; Nelson et al., 2017). Despite these benefits, the interaction between topography and nitrification inhibitors on N dynamics and corn productivity in claypan soils remains underexplored. This warrants further investigation. This research determined the optimum nitrogen (N) application rate and evaluated the efficacy of nitrification inhibitors, nitrapyrin (N-serve) and pronitridine (Centuro), on corn productivity across three different topographic positions (i.e., shoulder, backslope, and footslope).

## MATERIALS AND METHODS

A field experiment was conducted in 2023 and 2024 at the Lee Greenley Jr. Memorial Research Farm (40.02328°N, 92.19179°W) near Novelty, MO. The soil series of the experimental field is classified as Kilwinning silt loam (Fine, smectitic, mesic Vertic Epiaqualfs) and Putnam silt loam (Fine, smectitic, mesic Vertic Albaqualfs) with a saturated hydraulic conductivity of <0.01 μm $s^{-1}$. The experiment layout was a split-plot design with four replications. The main plots were three topographic positions: shoulder, backslope, and footslope classified similarly to Singh et al. (2020) using the Topographic Positioning Index (TPI) model. The sub-plots were N application rate treatments applied as anhydrous ammonia (AA) at 60 lb N $ac^{-1}$ (60 N), 120 lb N $ac^{-1}$ (120 N), 180 lb N $ac^{-1}$ (180 N), and 240 lb N $ac^{-1}$ (240 N), along with combinations of 120 lb N $ac^{-1}$ + Pronitridine (120 N + Pronitridine), 120 lb N $ac^{-1}$ + nitrapyrin (120 N + Nitrapyrin), 180 lb N $ac^{-1}$ + Pronitridine (180 N + Pronitridine), and 180 lb N $ac^{-1}$ + nitrapyrin (180 N + Nitrapyrin) along with a non-treated control (0 N; NTC). The plot size was 10 ft wide and varied based on the modeled topographic position layout. Corn was planted using a Kinzee planter at a row spacing of 30 inches wide rows and at a seeding rate of 35,000 seeds $ac^{-1}$.

Corn was harvested using a commercial combine equipped with a yield monitor calibrated for weight accuracy. The yield monitor was set to collect point yield data every second, capturing parameters such as duration, swath width, distance, track degree, moisture content, and mass flow. The collected point yield data were processed using Ag Leader SMS software, and further prepared for analysis in ArcGIS Pro v3.1. Quality control measures were applied to eliminate likely erroneous data points based on the following criteria: duration <0.99 s or >1.01 s, swath width ≠10 ft, distance <3 ft, track degree >10° & <170° or 90° & <350°, moisture >22%, and yield >300 bu $ac^{-1}$. The cleaned data were then overlayed with topographic positions and nitrogen treatments to extract the respective yield points. Corn grain yield was adjusted to 15% moisture content before data analysis. The GLIMMIX procedure in SAS was used to compare the means at $p=0.05$.

## RESULTS

Rainfall varied significantly between the two site years, with very (597mm) rainfall in 2023 (270 mm), compared to the 2024 cropping season (597 mm). Following the rainfall patterns, grain yields at all three topographic positions varied significantly across N rate treatments in 2023 and 2024 at $p < 0.05$.

**Shoulder (SH) Position:** On the SH 2023, 180 N treatment recorded the highest grain yield, producing 144 bu $ac^{-1}$, significantly greater than NTC (96 bu $ac^{-1}$) on SH. Yields of 120 N + Nitrapyrin were statistically similar to 180 N at 146 bu $ac^{-1}$. The 240 N treatment achieved 135 bu $ac^{-1}$, comparable to 180 N + Pronitridine (138 bu $ac^{-1}$) and 180 N + Nitrapyrin (135 bu $ac^{-1}$), indicating a NI's effectiveness in lowering the N application rate.

In 2024, the 240 N treatment had the highest yield 234 bu $ac^{-1}$ which significantly outperformed all other treatments. The 180 N treatment produced 214 bu $ac^{-1}$, while the 180 N + Pronitridine and 180 N + Nitrapyrin had similar yields (209 bu $ac^{-1}$ and 203 bu $ac^{-1}$ respectively). Treatments receiving no N had the lowest yield (71 bu $ac^{-1}$) which highlights the substantial benefits of applying N to the crop (Table 1).

**Backslope (BS) Position:** In 2023, the highest grain yield was observed with 180 N + Nitrapyrin which produced 152 bu $ac^{-1}$, followed by 180 N at 150 bu $ac^{-1}$. Both treatments 240 N and 180 N + Pronitridine resulted in 145 bu $ac^{-1}$ yield which was 58 bu $ac^{-1}$ higher than the NTC. In 2024, the 240 N treatment had significantly greater yields at 230 bu $ac^{-1}$ while 180 N + Pronitridine and 180 N + Nitrapyrin yielded 5 to 9 bu $ac^{-1}$ higher in grain yield compared to 180 N (Table 1).

**Footslope (FS) Position:** During 2023**,** 180 N + Nitrapyrin (148 bu $ac^{-1}$) had the highest grain yields, which was 10 bu $ac^{-1}$ higher to the yields of 180 N + Pronitridine (Table 1). Grain yields for the N rate treatments, 120 N and 120 N + Pronitridine were similar at 134 bu $ac^{-1}$ and 133 bu $ac^{-1}$, respectively. In 2024, 180 N + Nitrapyrin. had 178 bu $ac^{-1}$ grain yields that were 4 to 8 bu $ac^{-1}$ higher than 180 N+ Pronitridine and 240 N. The lowest yields were recorded with no N application, showing the continued benefits of a nitrogen application at the FS.

**Table. 1**. Corn grain yields at Shoulder, Backslope, and Footslope topographic positions in 2023 and 2024. Means followed by similar letters within a column are not significantly different at p<0.05.

| | **Shoulder** | | **Backslope** | | **Footslope** | |
|---|---|---|---|---|---|---|
| **N-rate treatment** | **2023** | **2024** | **2023** | **2024** | **2023** | **2024** |
| lb $ac^{-1}$ | ----------------------------------bu $ac^{-1}$---------------------------------- | | | | | |
| 0 N† | 96 d | 71 i | 87 e | 61 i | 94 g | 57 i |
| 60 N | 122 c | 110 h | 123 d | 110 h | 119 f | 89 h |
| 120 N | 135 b | 162 f | 144 c | 165 f | 134 cd | 138 f |
| 180 N | 144 a | 214 b | 150 ab | 202 d | 141 b | 162 d |
| 240 N | 135 b | 234 a | 145 c | 230 a | 126 e | 168 c |
| 120 N + Pronitridine | 126 c | 157 g | 143 c | 168 e | 133 d | 153 e |
| 120 N + Nitrapyrin | 146 a | 177 e | 143 c | 158 g | 127 e | 126 g |
| 180 N + Pronitridine | 138 b | 209 c | 145 bc | 211 b | 138 bc | 174 b |
| 180 N + Nitrapyrin | 135 b | 203 d | 152 a | 207 c | 148 a | 178 a |
| *p-value* | <0.0001 | <0.0001 | <0.000 | <0.0001 | <0.0001 | <0.0001 |

†non-treated control with no nitrogen and nitrification inhibitor, 0 N; 60 lbs N $ac^{-1}$ with no nitrification inhibitor, 60 N; 120 lbs N $ac^{-1}$ with no nitrification inhibitor, 120 N;180 lbs N $ac^{-1}$ with no nitrification inhibitor, 180 N; 240 lbs N $ac^{-1}$ with no nitrification inhibitor, 240 N; 120 lbs N $ac^{-1}$ with Centuro, 120 N + Pronitridine; 120 lbs N $ac^{-1}$ with N-Serve, 120 N+ Nitrapyrin; 180 lbs N $ac^{-1}$ with Centuro, 180 N+ Pronitridine; 180 lbs N $ac^{-1}$ with N-Serve, 180 N+ Nitrapyrin.

## CONCLUSION

Corn grain yields were higher in the wet year (2024) across all topographic positions. The 240 lb N $ac^{-1}$ treatment achieved the greatest yields. Particularly at the shoulder (234 bu $ac^{-1}$) and backslope (230 bu $ac^{-1}$) positions. In contrast, the dry year (2023) had more comparable yields across various N treatments. This indicated limited benefits from higher N rates under moisture-limited conditions. Nitrification inhibitors like nitrapyrin and pronitridine had substantial yield increases in 2024, especially at the FS, highlighting their effectiveness in reducing nitrogen losses during wetter conditions. The non-treated control consistently had the lowest yields, with a significant decline in the wet year. This showed the importance of nitrogen applications for optimal production. Overall, nitrogen management strategies showed varied effectiveness depending on the year's moisture conditions, with higher N rates and inhibitors proving more beneficial during wet conditions across the topographic positions.

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