WEEKLY VS SINGLE NITROGEN FERTILIZER APPLICATION ON CORN

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ABSTRACT

Synchronizing nitrogen (N) supply with corn N demand is central to N management, because N that remains in the soil when the crop is not taking it up is vulnerable to loss. Optimal N rate and timing vary with weather and soil conditions, and process-based models such as the Agricultural Production Systems sIMulator (APSIM) could help predict responses but need to be evaluated against field data. As part of the Iowa Nitrogen Initiative (INI), we evaluated the effects of N fertilizer timing and application rate on corn yield in a field experiment conducted near Ames, Iowa, using a randomized complete block design with four replicates. Twelve treatments were selected, varying in rate and application timing of urea. Soil nitrate (NO_3-N, 0-1 ft) was sampled weekly until physiological maturity, and aboveground biomass was sampled at four growth stages for five treatments: a zero-N control; 75, 150, and 300 lb N ac^{-1} at planting; and 150 lb N ac^{-1} applied in weekly increments from late May through late July. Grain yield was measured for all plots, and the five intensively sampled treatments were simulated in APSIM using site-specific soil and weather data. The objectives were to evaluate how N fertilizer rate and timing affect soil NO_3-N, corn growth, and yield, and to assess how well APSIM reproduces the observed data. Preliminary observations from the 2026 growing season suggest that weekly application timing maintained lower soil NO_3-N during the season than a single application of the same rate at planting. Analysis of crop response and model performance is ongoing, and these results will help inform strategies for matching N supply to crop demand.

INTRODUCTION

One central challenge in nitrogen (N) management is supplying sufficient N to meet crop demand while avoiding excess plant-available N in soil that is vulnerable to environmental losses. N fertilizer is an expensive but necessary input for many rainfed continuous corn cropping systems. N fertilizer production depends on fossil energy, and increased fossil fuel prices could change how N fertilizer is used (Dinnes et al., 2002), which makes improved N management important for profitability as well as for its effects on the environment and crop productivity.

Much of the nitrogen management literature focuses on achieving synchrony between crop N demand and N supply without creating N deficiency or excess. The risk of N loss through leaching, denitrification, and volatilization increases as the time between N application and crop uptake increases (Dinnes et al., 2002), and losses increase with the amount of plant-available N present in the soil at any given time (Cassman et al., 2002).

The potential for losses of N is highest when the pool of plant-available N exceeds crop demand.

However, crop N supply is not determined by fertilizer applications only. Corn also receives N from indigenous soil sources, especially through mineralization of soil organic matter (SOM) and crop residues. It is difficult to predict the supply of indigenous soil N because it varies over time and among fields, and soil N can vary considerably within a single field (Cassman et al., 2002; Dinnes et al., 2002).

Both fertilizer rate and timing therefore determine how to maintain enough plant-available N when crop demand is high and avoid large soil N pools when the crop demand is low. Timing matters because corn N demand is lower at early vegetative growth, then increases rapidly around V6 (Clark et al., 2020). Splitting fertilizer applications and delaying some N to be supplied later in the season can reduce the period of high soil N pools during low crop demand, but the benefits of split applications are not consistent (Clark et al., 2020). Delaying most N until mid-season or increasing the N rate does not necessarily increase crop growth or yield. Across 49 site-years in the Midwest, Clark et al. (2020) found that responses such as soil nitrate and grain yield to split versus single N applications depended on weather and soil conditions.

Weather adds layers of complexity to N management. Rainfall amount and distribution affect yield potential and can influence how N interacts with its environment. Too much precipitation when soil N is high can increase leaching and denitrification, but too little rainfall after N application may prevent fertilizer from being adequately incorporated into the root zone (Clark et al., 2020). In part, the success of timing N applications depends on the weather that follows application, which highlights the importance of weather data and forecasting in developing N recommendations.

Effective N recommendations depend on understanding interactions among soil, weather, crop, and management, and layers of complexity are added when considering indigenous sources of N already present in the soil. Improving predictions of soil and crop N dynamics requires field experiments that compare contrasting N management strategies and evaluate how well process-based models reproduce the observed results.

The objective of this study was to assess how N fertilizer rate and timing, specifically a single application at planting versus weekly in-season applications, affect soil NO_3-N dynamics in corn, as a basis for future crop response analysis and model evaluation.

MATERIALS AND METHODS

As a part of the Iowa Nitrogen Initiative (INI), a field experiment was conducted at the Iowa State University Agricultural Engineering and Agronomy Research Farms near Ames, Iowa, during the 2026 growing season. Corn was planted on 8 May 2026 in a randomized complete block design with four replications. Twelve treatments were included, varying in rate and application timing of urea. Intensive soil and plant measurements were collected for five treatments: a zero N control; 75, 150, and 300 lb N ac^{-1} at planting, and 150 lb N ac^{-1} applied in weekly increments from late May through late July.

Soil samples were collected weekly from a 0-1 ft depth from late May until physiological maturity (R6) and analyzed for NO_3-N. Aboveground biomass was sampled at four growth stages by collecting, drying, and weighing five plants per plot. Grain yield

was measured for all twelve treatments with a combine over a 30-ft length of each plot, harvesting either the center four or center eight rows depending on the plot.

Soil NO_3-N, biomass, and yield were averaged across replications to obtain treatment means. Biomass and yield data were checked for normality in R, and treatment differences were evaluated with Fisher's LSD test ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Soil NO_3-N Patterns

Early-season soil NO_3-N patterns reflected the amount of N applied, with higher preplant rates producing larger soil NO_3-N pools at the first sampling in late May (Figure 1). Soil NO_3-N declined in all rates and timings from late June to early July, coinciding with the period of rapid increase in corn N demand during vegetative growth. By early August, most treatments were similar to the zero-N control, except for the 300 lb N ac^{-1} treatment, which remained a bit higher than others through the rest of the season. Variability among replicates was large on some sampling dates and still requires exploration.

The weekly treatment kept soil NO_3-N relatively low and stable throughout the season, generally close to the control early in the season. Whether the lower soil NO_3-N pools in the weekly treatment translate into reduced N loss or affect crop N remains to be determined.

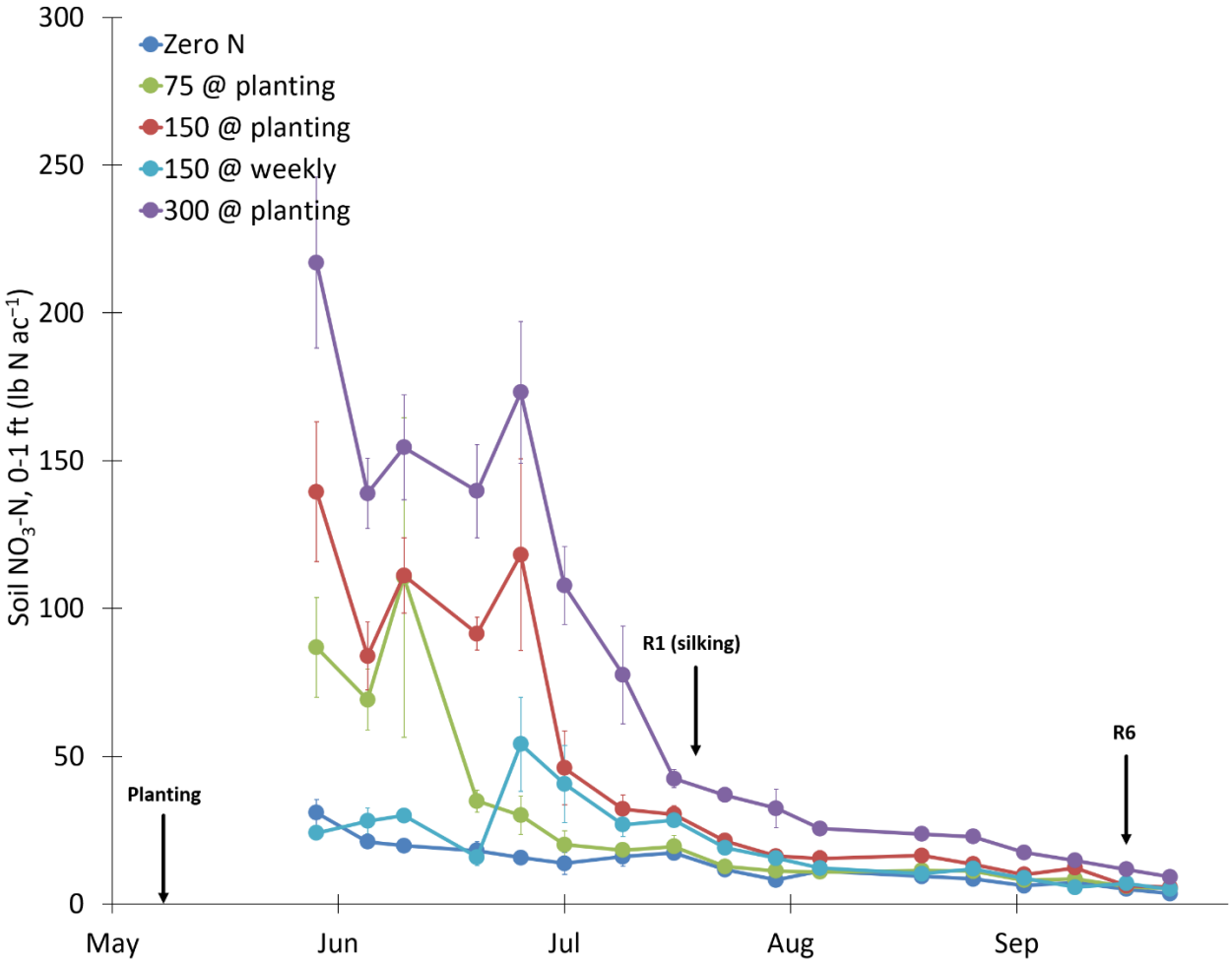


Figure 1. Soil NO_3-N (lb N ac^{-1}, 0-1 ft depth) during the 2026 growing season for the zero-N control; 75, 150, and 300 lb N ac^{-1} applied at planting; and 150 lb N ac^{-1} applied in weekly increments. Arrows indicate planting, silking (R1), and physiological maturity (R6). Error bars represent ± SE (n = 4).

Ongoing Work

Aboveground biomass and grain yield are still being analyzed and are not reported here. The five intensively sampled treatments were also simulated with APSIM (Holzworth et al., 2014) using site-specific soil and weather data. Evaluation of how well the model reproduces the observed soil NO_3-N values is ongoing, and the model will then be used to estimate N losses that were not measured directly.

ACKNOWLEDGEMENTS

We thank Natan Mendes Freire, Tomas Ballester Molina, Alvaro Quintano Vazquez, and Andrew Rupiper for assistance with field and lab work.

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