Can varying nitrogen fertilization timing and rate improve the environmental impact of corn under future climate?

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Introduction

Corn requires substantial nitrogen (N) fertilizer inputs to sustain financially tenable yields. However, residual N not used by crops becomes environmentally problematic as it is microbially transformed into nitrate (NO_3^-), an important water pollutant, and lost to the atmosphere as the potent greenhouse gas nitrous oxide (N_2O). Future climate scenarios also suggest that shifts toward greater Spring precipitation could impact corn production and N losses.

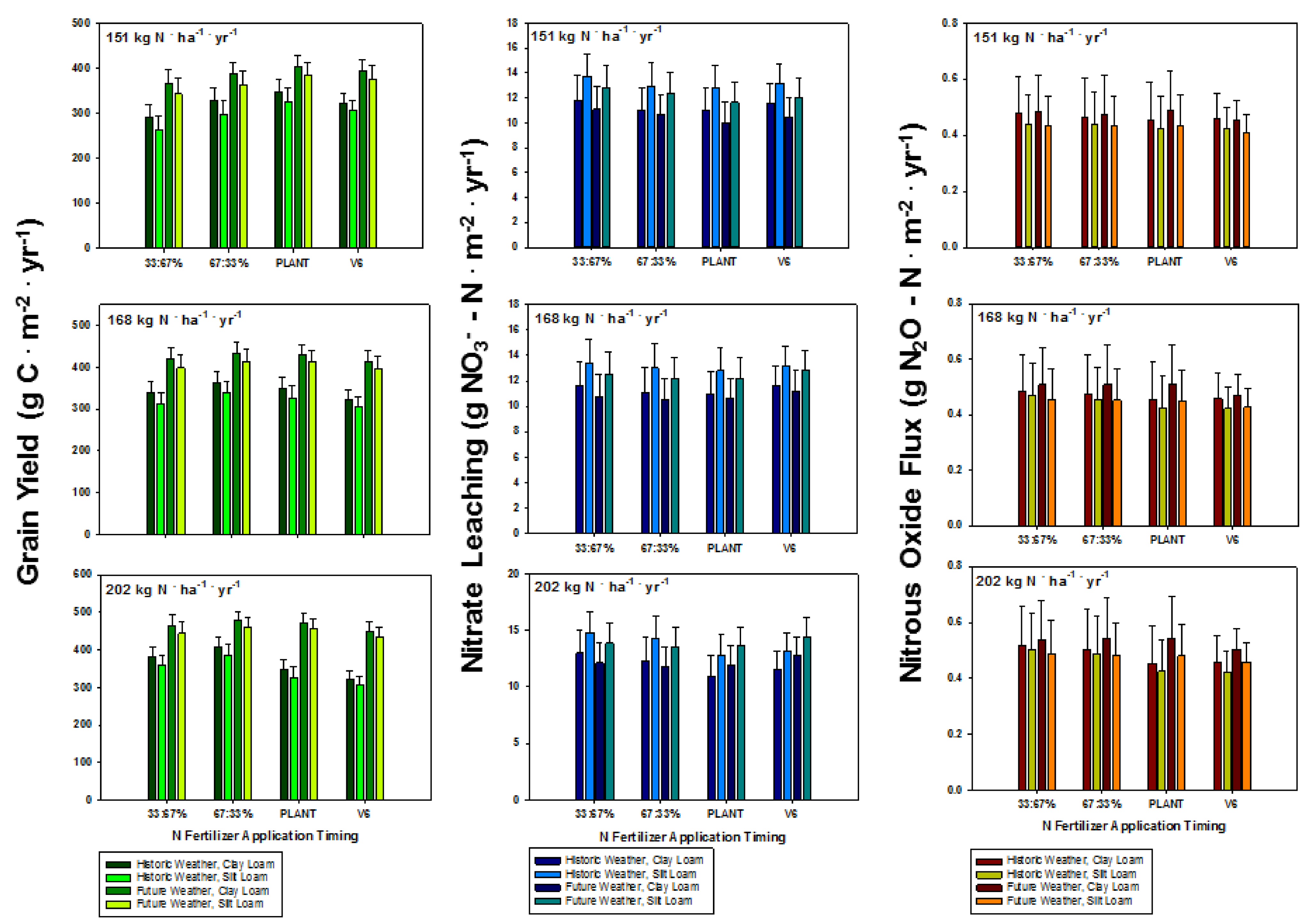
A potential solution for minimizing N losses while maintaining yields under future climate is to optimize the rate and timing of N fertilization. Adequately timing N additions with crop needs can potentially increase N use efficiency, and reduce excess N lost to water sources and the atmosphere. To that end, we performed simulation experiments using both historical and predicted future weather scenarios to test the hypothesis that splitting N applications between the time of planting and the V6 growth stage are strategies that can increase corn yield and minimize N loss.

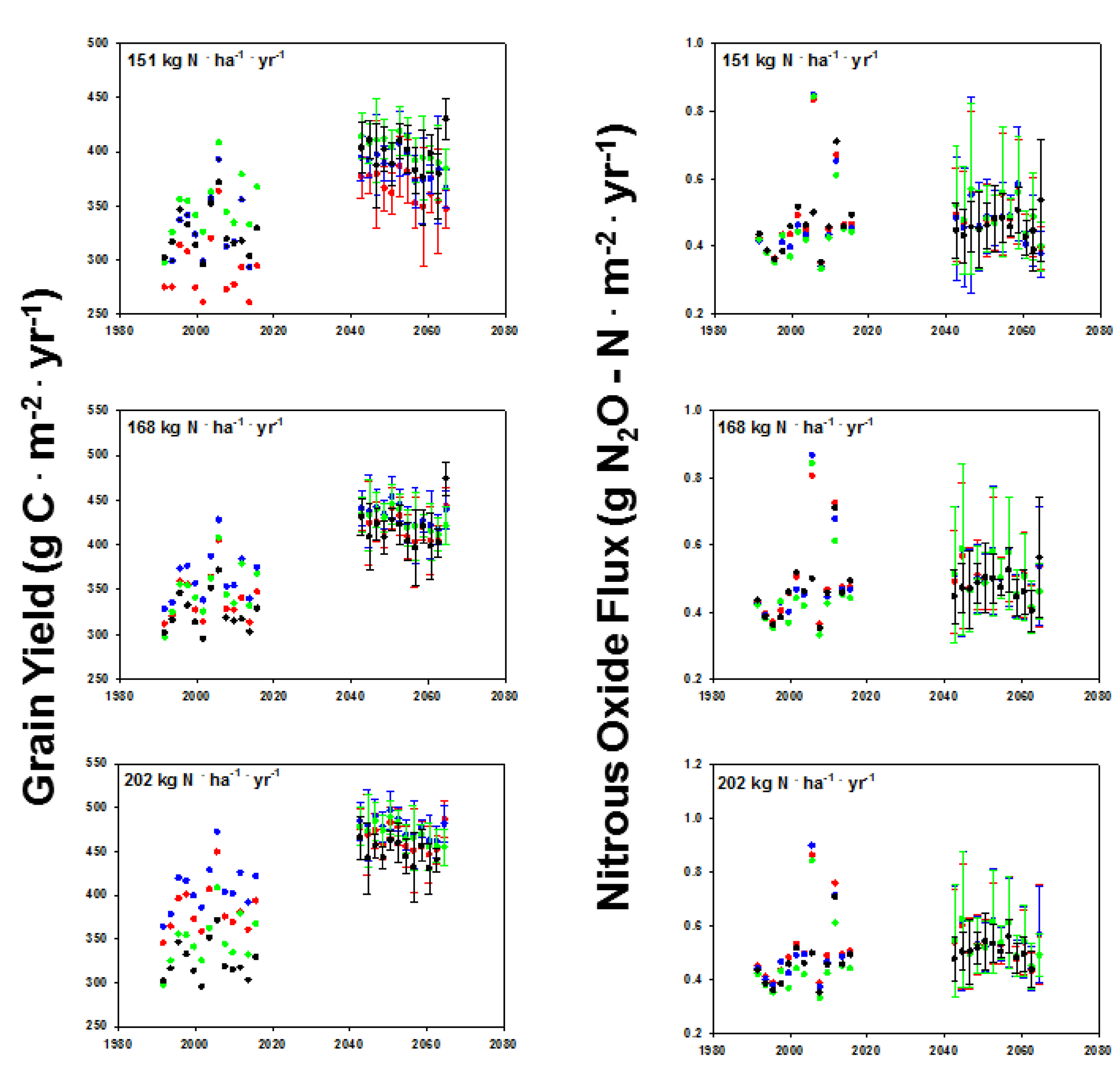
Experimental Procedure

We employed the DAYCENT biogeochemical model to test for differences in corn grain yield and N losses, across 3 N fertilization rates (151, 167 & 202 kg N · ha^{-1} · yr^{-1}), and 4 different application timing strategies (application only at planting, application only at V6 growth stage, 33:67% planting/V6 split, and 66:33% planting/V6).

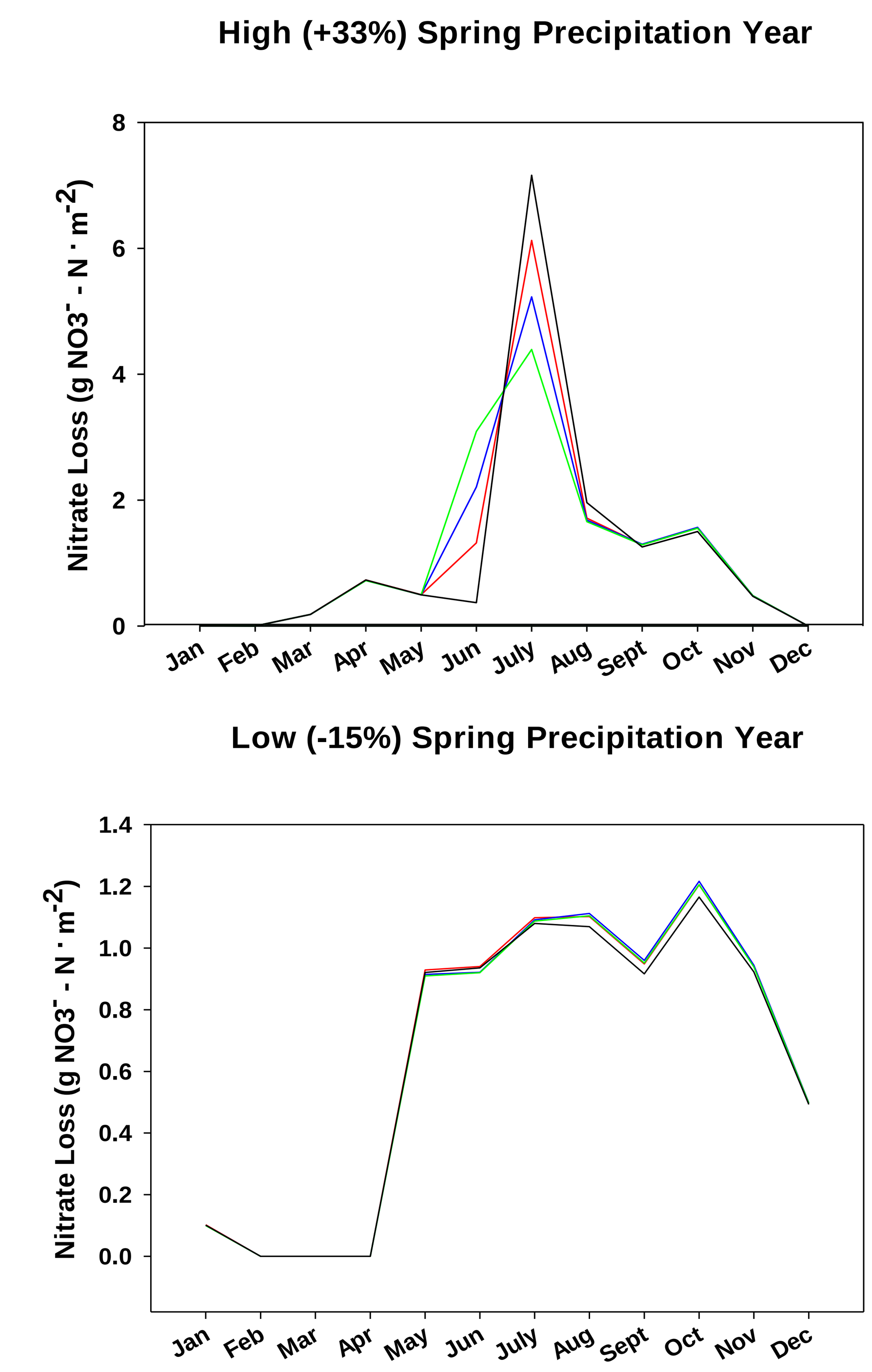
The results presented are simulations based on Gilmore, IA, as DAYCENT was previously calibrated for this site. The model was run using daily historic weather, and future weather projections based on a suite of 5 downscaled climate models.

Corn Yield — NO_3^- Leaching — N_2O Flux





33:67% Split N Application
67:33% Split N Application
All N at Planting
All N at V6



Conclusions

- Yield generally increased under future climate
- NO_3^- loss generally declined under future climate (more efficient uptake?)
- Split N strategies did not have significant effects on N loss compared to single N application at planting, but split N did increase yield at N rates of MRTN and greater
- Varying N application timing appears to have the greatest impact on nitrate loss in years with greater than average Spring precipitation (~ 22% of future Spring months had > 20% more precipitation compared to historic data in our simulations).

Recommendations

- Split N application is beneficial at higher N rates
- Potential for greater N losses with split applications in high Spring precipitation years
- More study needed to determine optimal N rates and timing under future climate
- We will further this work using probabilistic climate analyses (i.e., Cligen in concert with DAYCENT)

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