LESS NITROGEN, SAME YIELD: EVIDENCE FROM 45 SITE-YEARS OF SENSOR-BASED MAIZE NITROGEN MANAGEMENT IN THE U.S. MIDWEST

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Abstract.

Improving nitrogen use efficiency (NUE) while maintaining maize productivity remains a central challenge for irrigated corn systems in the U.S. Midwest. Sensor-based, in-season nitrogen (N) management has been around for many years. Yet US Midwest farmers reported that lack of information about the value of this approach and the fear of losing yields when reducing the N rate were the top barriers to adoption. In-season N management enables better synchronization of N supply with crop demand, yet multi-environment validation at scale remains limited. The objective of this study was to evaluate the agronomic and economic performance of sensor-guided N management across irrigated maize fields in Nebraska (USA).

This research synthesized results from 45 site-years of irrigated maize experiments conducted through the Nebraska On-Farm Research Network under a USDA-NRCS Conservation Innovation Grant. Trials compared producer-standard N management with an imagery-driven in-season recommendation system. Studies were implemented under commercial production conditions using replicated trial designs. Key metrics included grain yield, total N applied, nitrogen use efficiency, marginal net return, and residual nitrates in the soil after harvest. Across 45 site-years (2021-2025), the sensor-based imagery approach consistently recommended a reduction in N rates of 45 kg N/ha with no statistical yield penalty. Despite lower N inputs, grain yield was statistically similar between treatments, averaging 14,600 kg ha $^{-1}$ for the sensor-based approach and 14,740 kg ha $^{-1}$ for the grower standard. Soil samples collected after harvest in 20 site-years showed that there are fewer residual nitrates in the first 60 cm of soil when implementing sensor-based approaches, showing the potential benefits to reduce the *contribution of nitrates to underground water sources, which is an extended problem across Nebraska and other Midwest USA states. Marginal net return analysis of the sensor-based practices shows a benefit of 54 u$s/ha increase compared to growers' management.*

A survey after the project concluded showed that 71% of participating farmers decided to continue evaluating the technology in their fields after they tested in this project. With 36% of the farmers are adopting the technology (implementing the sensor-based approach in 50% or more fields in their farms). Overall, this large-scale on-farm evaluation demonstrates that sensor-based nitrogen management can maintain maize productivity while improving NUE and reducing N inputs in Midwest irrigated systems. Continued refinement of decision algorithms, integration with weather and soil data streams, and expanded multi-year validation will be critical to fully capture the technology's potential for both economic and environmental outcomes.

.***Keywords.***
Site-specific management, fertigation, precision agriculture, imagery, vegetation index, NDRE.

Introduction

Sensor-Based Nitrogen Management Sensor-based nitrogen management is a precision agriculture approach that uses in-season imagery (from cameras/sensors mounted on satellites, drones, or ground vehicles to determine whether additional nitrogen (N) fertilizer is needed during the growing season. Instead of applying a fixed rate of N across the entire field all at once, this technology allows farmers to match nitrogen supply with the actual needs of the crop—both in space and time.

How the Technology Works

Plants reflect light in ways that reveal their health and nitrogen status. Specialized sensors—mounted on equipment, drones, or irrigation systems—measure this reflected light and calculate vegetation indices such as NDVI or NDRE. These indices are strongly related to crop vigor, biomass, and nitrogen content. To interpret these measurements, farmers typically establish a reference strip (also called an N-rich strip) in the field where nitrogen is not limiting. By comparing the rest of the field to this well-fertilized area, the system can estimate whether the crop is experiencing nitrogen stress and how much additional fertilizer is needed. Using this information, algorithms generate in-season, site-specific nitrogen recommendations, which can be applied immediately using variable-rate equipment or fertigation systems (applying nutrients through irrigation).

Why It Matters

Traditional nitrogen management often relies on pre-season estimates and uniform application rates. However, crop nitrogen needs vary across fields and throughout the season due to weather, soil variability, and crop growth conditions. Sensor-based systems address this variability by enabling adaptive, data-driven decisions. Sensor-based nitrogen management does not replace farmer expertise—it enhances it.

Potential Benefits

Improved nitrogen use efficiency (NUE): Applying the right amount at the right time reduces waste and increases fertilizer recovery by the crop

Reduced input costs: Many studies show lower total nitrogen applied without sacrificing yield

Maintained yields: Matching nitrogen to crop demand helps avoid both deficiency and excess

Environmental protection: Reduces nitrogen losses to water (leaching) and air (emissions), protecting natural resources

Materials and methods

Results

Conclusions

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Conclusion

Acknowledgments

Put any acknowledgments, such as thanks to contributing individuals or organizations, here.

References