LESS NITROGEN, SAME YIELD: RESULTS FROM 45 SITE-YEARS OF SENSOR-BASED NITROGEN MANAGEMENT IN IRRIGATED CORN IN NEBRASKA

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ABSTRACT

Sensor-based nitrogen (N) management may improve nitrogen use efficiency (NUE) by matching in-season fertilizer applications to crop N demand, but its performance must be demonstrated under commercial farming conditions. This study evaluated sensor-based fertigation compared with grower N management across 45 irrigated corn site-years in Nebraska from 2021 to 2025. Replicated field-scale treatments compared the grower's standard N management with a sensor-based approach. A base N rate was applied across treatments, and the sensor-based treatment used N-deficient canary plots, high-N reference plots, and weekly satellite imagery to assess crop N status and trigger 35 kg N/ha fertigation increments when additional N was required. Treatments were harvested using commercial yield monitors. Across 45 site-years, sensor-based management reduced fertilizer N application by an average of 52 kg N/ha compared with grower management while reducing grain yield by only 150 kg/ha. Consequently, partial factor productivity of fertilizer N (PFP-N) increased from approximately 76 to 100 kg grain/kg N, representing an improvement of approximately 32%. Despite the substantially lower N input, sensor-based management increased partial profit by approximately $27/ha. Postharvest soil sampling at four grower sites also showed lower residual nitrate under sensor-based management, averaging 6.0 ppm versus 11.5 ppm under grower management. Results from this multi-year, field-scale on-farm research network demonstrate that sensor-based fertigation can substantially reduce N fertilizer use while maintaining corn productivity and profitability. Integrating satellite-based crop monitoring with strategically timed fertigation offers a practical way to improve NUE and reduce residual soil nitrate in irrigated corn production systems.

INTRODUCTION

Precision nitrogen (N) management offers opportunities to improve nitrogen use efficiency (NUE), maintain crop productivity, and reduce environmental losses by better matching fertilizer applications with crop N demand. Advances in remote sensing, crop monitoring, and variable-rate technologies have enabled more informed N management decisions. However, adoption of these technologies remains limited, particularly because of uncertainty about their economic benefits, technical complexity, and the need for reliable field-scale validation. Demonstrating consistent agronomic and economic benefits under commercial farming conditions is essential to increase grower confidence and accelerate adoption.

Nebraska leads the nation in irrigated corn production and in developing and evaluating precision agriculture technologies. Its extensive irrigation infrastructure provides opportunities to implement in-season N management through fertigation. Nevertheless, conventional N management practices remain common, and the adoption of sensor-based approaches is constrained by limited information about their value, technology costs, and management requirements. On-farm research and demonstration programs play a critical role in addressing these barriers by allowing growers to evaluate technologies under their own production conditions.

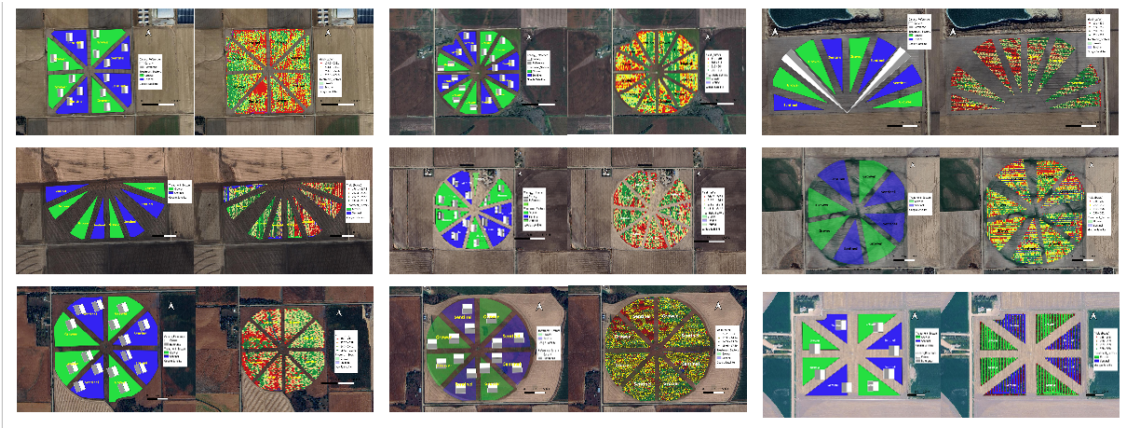
The University of Nebraska–Lincoln, in collaboration with commercial growers, has established an on-farm research network to evaluate sensor-based N management using satellite imagery, crop N status indicators, and fertigation. This study summarizes results from 45 site-years conducted between 2021 and 2025, comparing sensor-based N management with growers' standard practices. The objectives were to quantify differences in fertilizer N use, grain yield, NUE, and profitability, while demonstrating the potential of precision N management to support broader adoption in irrigated corn production systems.

MATERIALS AND METHODS

As part of the Precision Nitrogen Conservation Innovation Grant (USDA CIG 2021-2025), we conducted 45 site-year on-farm research experiments in Nebraska to evaluate sensor-based fertigation performance in corn. Two treatments were evaluated: growers and sensor-based fertigation (sensor-based). Grower's treatment represents each grower's current management practices that include a combination of one or more timings and an N rate determined by the grower. Sensor-based included a base N rate of 50 to 100 kg N/ha at planting or before planting, followed by a satellite-based assessment every week until R3 that will trigger a N application of 30 lb. N/ac if needed after each assessment. Treatments were placed in pies covering all the irrigation pivot. Reference plots (250 lb. N/ac) were distributed across the field to support the sensor-based approach in determining the sufficiency index (**Figure 1**). Along with the reference plot, we placed canary plots at an N rate 33 kg N/ha below the base rate. This plot allowed for early detection of N deficit. Plots were managed with an automatic pump and telemetry. We used a yield monitor capable of producing a yield map to harvest all on-farm trials. We cleaned the data following standard yield-map protocols and analyzed them while accounting for the spatial component of each yield data point. As part of the project end report, we conducted a survey and asked about adoption of this precision N management practice. Partial factor productivity of the fertilizer and partial profit were calculated combining all 45 sites and years. The price used was 0.2104 $/kg corn and 1.107$/kg N. Post-harvest nitrates soil sampling was conducted in a selection of sites to track residual nitrates.

RESULTS

Across 45 site-years, sensor-based nitrogen (N) management significantly reduced fertilizer N application compared with grower management, from 211 to 159 kg N/ha, representing a reduction of 52 kg N/ha (25%; $p < 0.0001$, **Figure 2**). Corn grain yield decreased slightly from 15.26 to 15.11 Mg/ha (0.15 Mg/ha; $p = 0.014$), representing a reduction of less than 1%. Consequently, partial factor productivity of N (PFP-N) increased significantly from 76.01 to 100.66 kg grain/kg N (32%; $p < 0.0001$). Despite the slight reduction in grain yield, sensor-based management increased partial profit



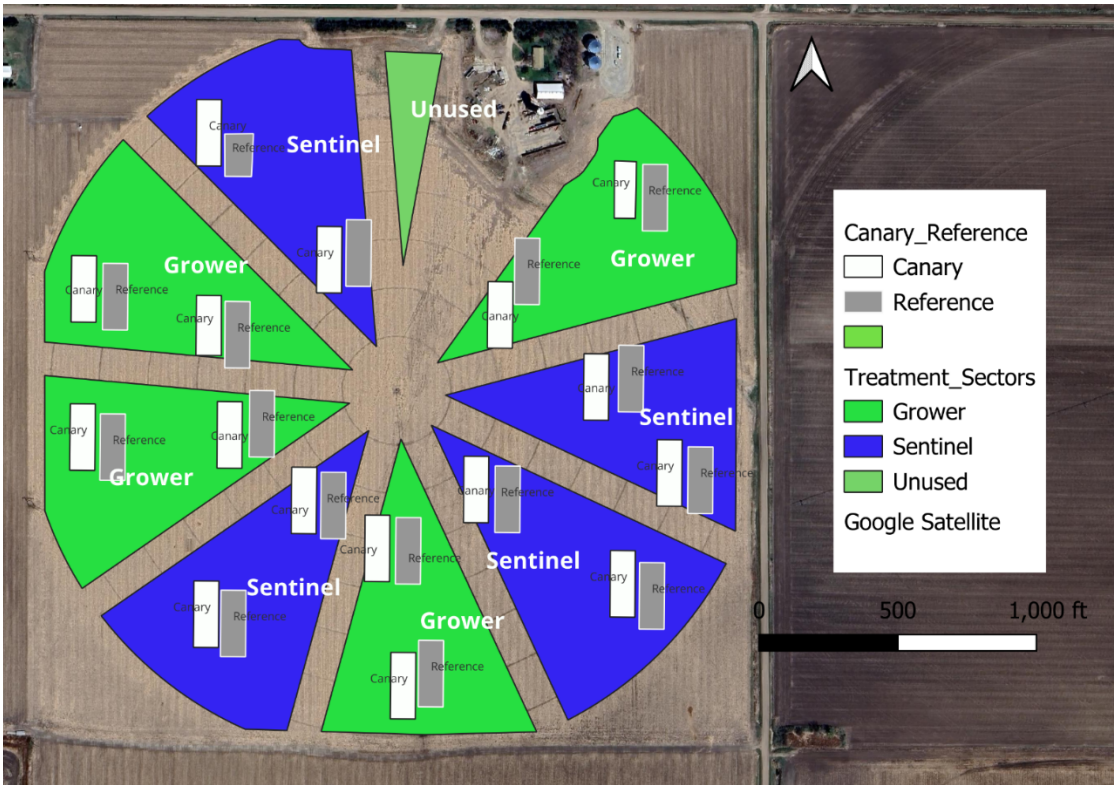


Figure 1. Treatment layout (grower- and sensor-based (Sentinel) and yield map for ten sites conducted in the 2025 growing season (top panel). Treatment layout and location of reference and canary plots in the field (bottom panel).

from $2,386 to $2,412/ha (+$26/ha; p = 0.005).These results demonstrate that sensor-based N management can substantially reduce fertilizer N inputs and improve NUE while maintaining high corn productivity and increasing profitability under commercial irrigated production conditions in Nebraska.

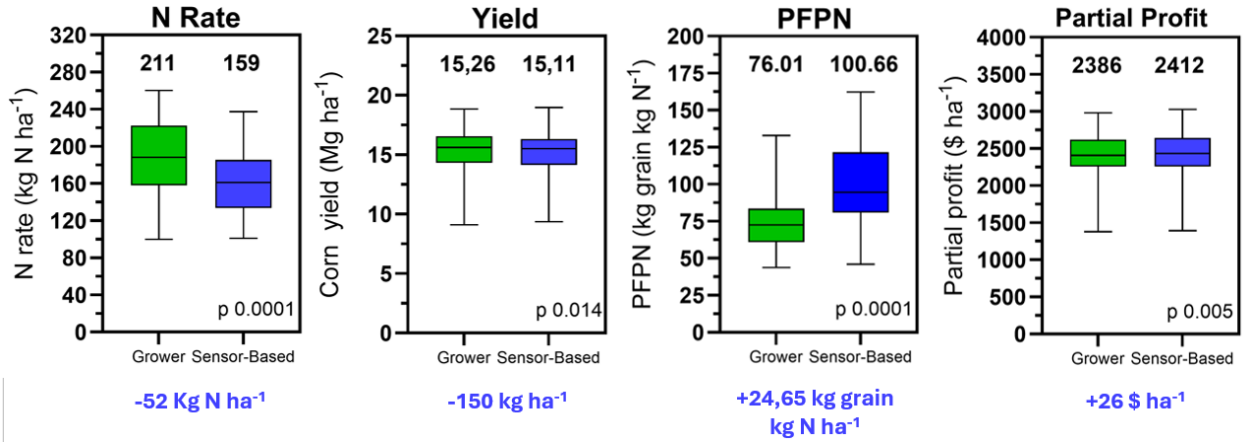


Figure 2. Nitrogen rate, grain yield, partial factor productivity of the fertilizer, and partial profit for grower- and sensor-based treatments.

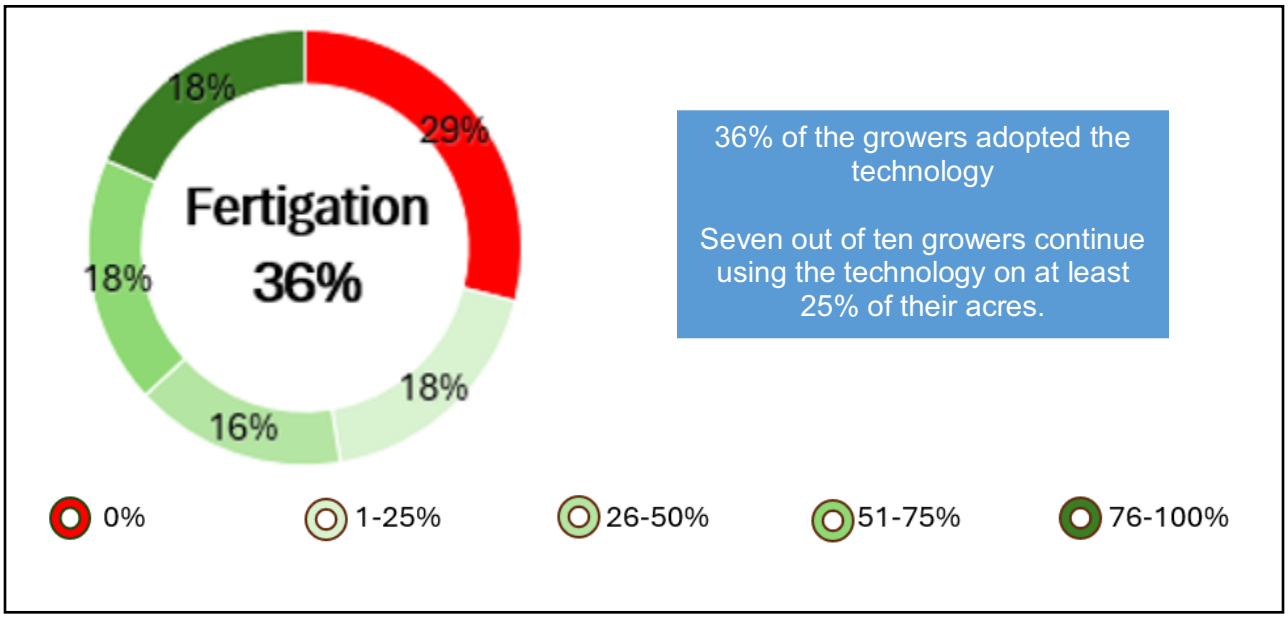


Figure 3. End-of-project survey of CIG participating growers on adoption of sensor-based fertigation practices. The number inside the pie shows adoption (more than 50% of farms adopted the practice). Seven out of ten growers continue using the technology in at least 25% of their operations.

Postharvest soil sampling at four grower sites also indicated lower residual nitrate under sensor-based management, averaging 6.0 ppm compared with 11.5 ppm under grower management.

An end-of-project survey of participating growers showed that 35% adopted sensor-based fertigation management, as they implemented it on more than 50% of their acres

(**Figure 3**). Seven out of ten growers continued using the technology on at least 25% of their farms, which poses a promising adoption future for this management practice.

CONCLUSIONS

Sensor-based fertigation reduced N fertilizer application by 25% while decreasing corn yield by less than 1%, improving N use efficiency by 32%, and increasing partial profit by $26/ha. Lower residual soil nitrate concentrations suggest potential environmental benefits. Continued adoption by participating growers highlights the practical value of integrating satellite-based monitoring with in-season fertigation to improve N management in irrigated corn production systems.

REFERENCES

Amori, P.N., Heeren, D.M., Balboa, G.R., Puntel, L.A., Shi, Y., Rudnick, D., Luck, J., Wilkening, E., and Zhang, K. 2026. Optimizing in-season nitrogen management through satellite-guided fertigation in field-scale maize production. Computers and Electronics in Agriculture, 241, 111275.

Cano, P., Mandrini, G., Buckmaster, D., Arnall, B., Carroll, M., Sharda, A., Balboa, G., Carcedo, A., Hawkins, E., Fulton, J., de Borja Reis, A.F., Shannon, K., Sudduth, K., Kovács, P., Phillips, S., Zhou, J., Erickson, B., Ciampitti, I., 2026. Farmer perspectives on digital agriculture in the US Midwest. Agron. J. 118, e70268. https://doi.org/10.1002/agj2.70268

Cross, T.A. 2023. Assessment of sensor-based fertigation management performance in irrigated maize production. Master's thesis, University of Nebraska–Lincoln.

Paccioretti, P., Puntel, L., Córdoba, M., Mieno, T., Ferguson, R., Luck, J., Thompson, L., Balboa, G., 2025. Site-specific drivers of sensor-based nitrogen management in on-farm corn and wheat experiments. Front. Agron. 7. https://doi.org/10.3389/fagro.2025.1651522

Righetti, E. J., Favoretto, M., Gilardoni, F., Luck, J. D., & Balboa, G. R. 2025. Improving Maize Nitrogen Use Efficiency through Sensor-Based Fertigation Via on-Farm Research [Abstract]. CANVAS 2025, Salt Lake City, UT. https://scisoc.confex.com/scisoc/2025am/meetingapp.cgi/Paper/168147

Stansell, J.S. 2021. Development and automation of a sensor-based fertigation management framework for improved nitrogen use efficiency and profitability in irrigated row crop production systems. Master's thesis, University of Nebraska–Lincoln.