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Abstract.
Nitrogen (N) is an input that is vital for growth and productivity within the corn belt states of the U.S. However, when N as an input into agricultural cropping systems is often over-applied and thus not optimally utilized by the cropping system. Therefore, it is at risk of loss within the environment through processes of leaching, denitrification, and volatilization. This is a major concern in Nebraska, as the reality is that much of the state's groundwater has been contaminated with nitrates (NO_3^-) leaching from soil where the over-application of N – based fertilizers has occurred.
Therefore, a sensor-based fertigation management (SBFM) approach allows for a data driven decision support system to improve the efficiency of N management through fertigation events in irrigated agricultural landscapes. The SBFM approach has been repeatedly tested and improved to maximize the grower's need across Nebraska. However, recently it has been assessed to better understand how SBFM affects the residual nitrate concentrations. The objective of this study was to assess the SBFM approach in reducing residual nitrate levels within the soil and groundwater when compared to the grower's traditional approach. Post-harvest soil sampling was used to investigate the correlation between N at risk to leaching within the soil profile. Soil samples were taken from each treatment sector to test residual nitrate levels at 0-8" and from 8-24" depths. The results for each depth were then compared between the grower and the sensor-based approaches for the selected fields site.
Results from this sampling method may vary in response depending on the soil type present in the field site. The 2022 growing season results showed a statistical difference between the grower and sensor-based fertigation management at both depths for residual nitrates (ppm)..
Keywords.
Precision agriculture, Soil health, water quality, agricultural technology, Sensor-Based approach, Nitrates, Efficient nitrogen allocation, Sustainability.

Main Body

In 2022, the state of Nebraska contributed nearly 9.5 million acres planted for corn production (N.A., Accessed 2024). In the U.S., there is approximately 9.3 million irrigated acres for all crops according to the Nebraska Department of Agriculture. Therefore, extensive contribution of acres dedicated to corn production has made Nebraska a leading state for irrigated acres in the U.S. (Ates, A., 2023). Given the below average rainfalls and high temperatures through the growing season, a high presence of irrigation has been a necessity across the state. The most common being center-pivot sprinkler systems, micro irrigation such as subsurface, and surface irrigation. All of which was made possible by the vast Ogallala aquifer (Torell, L. A., 1990).

It is also common for producers to practice chemigation and fertigation events in conjunction with irrigation events across the state. Chemigation and fertigation practices represent the practices where a chemical or fertilizer is injected through an irrigation system. However, in some heavily irrigated areas in Nebraska are facing environmental impacts due to past nitrogen (N) applications exceeding corn uptake. Thus, resulting in excess N to be highly susceptible to nitrate leaching through the root zone into the groundwater. This process of leaching has since or could potentially harm public drinking water in areas where nitrate levels in the ground water exceed 10 ppm (Unit, G., 2020). The consumption of high nitrate levels grom groundwater has since been linked to methemoglobinemia and increased risk of cancer development (Ward, M. H., et al., 2018).

Inefficient N management, where more N is applied than the crop can utilize, has resulted in areas of critically high groundwater nitrate levels. Therefore, it is necessary for the management decisions being made in irrigated corn production to maximize nitrogen use efficiency (NUE). In context to Sensor Based Fertigation Management (SBFM), the approach presented in thus study, NUE represents the lb-N applied (fertilizer) per bushel of grain produced. The use of an SBFM approach would allow for improved NUE as it accounts for applications to be made during critical uptake periods, between V9 to V18 growth stages. This approach would also reduce potential leaching as it minimizes the N that isn't being utilized by providing nitrogen closer to the critical uptake period (Cross, T., 2023). Therefore, how efficient a producers nitrogen management system is can directly impact the environment, public health, and their operation's profitability.

The Sensor Based Fertigation Management (SBFM) represents the most recent advancement is data driven, sensor-based decision support systems. The sensor-based fertigation approach has been repeatedly tested and improved to maximize the grower's need across Nebraska. However, recently it has been assessed in four field sites (tbl.1) to better understand how sensor-based fertigation management affects the residual nitrate concentrations. The objective of this study was to assess the sensor-based fertigation approach in reducing residual nitrate levels within the soil and groundwater when compared to the grower's traditional approach.

Table 1. Background information of the four field sites in the years 2022 and 2023.

Site	Year	County	Soil Type	Soil Organic Matter (%)
I	2022	Hall	Hord silt Loam, Hall silt loam	2.60
II		Hall	Holder Loam	2.70
I	2023	Butler	Ovina Thurman Complex, Muir Silt Loam, Gibbon Silty Clay Loam	3.00
II		Clay	Crete Silt Loam and Hastings Silt Loam	3.00

Methods

The primary sampling methods utilized to capture this effect in agricultural landscapes differ between field sites. The first being soil sampling to investigate the correlation between nitrogen at risk to leaching within the soil profile post-harvest. To do so, soil samples were taken from each treatment sector to test residual nitrate levels at 0-8" and from 8-24" depths. The results for each depth were then compared between the grower and the sensor-based approaches for the selected fields site. While the second utilizes lysimeter equipment installed at 4-foot depth to sample the nitrate concentrations within groundwater samples during the growing season. Water samples were collected from lysimeters nitrate-N from the V8 – R3 growth stage in irrigated maize production. It should be noted that data collected from the lysimeters varied significantly, possibly due to installation or soil conditions and was not presented further.

Figure

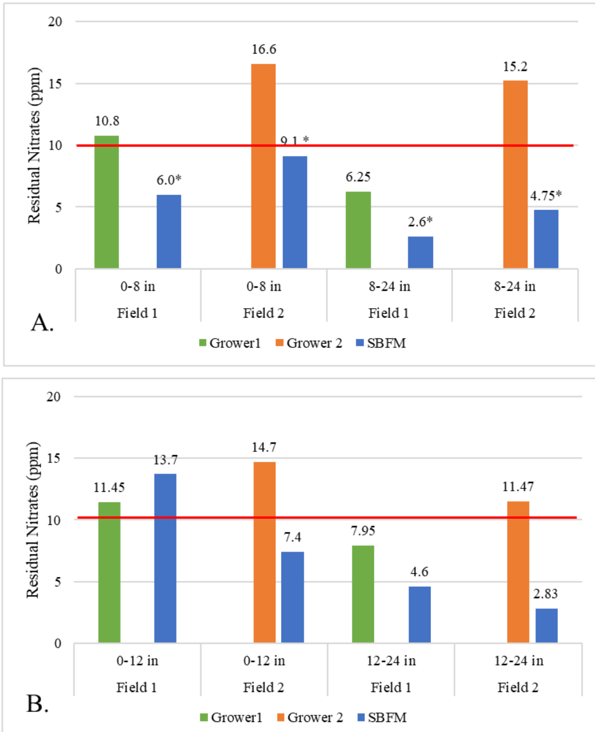

Figure 1A. Bar graph for the mean residual nitrate level (ppm) for each field site in the year 2022 in, significantly (*) at ($p < 0.05$) using ANOVA test. Figure 1B. Bar graph for the mean residual nitrate level (ppm) for each field site in the year 2023.

Conclusion

In 2022 and 2023, the Sensor based fertigation management was assessed for residual nitrates in four field sites across Nebraska. The residual nitrates in this study represent the approximate amount of nitrogen left over within a field site after the growing seasons management strategies. Each field site was sampled to compare the grower's management decisions to the sensor-based management methods. The results found that on average the growers' management showed residual nitrates averaging 11.50 ppm while the sensor-based sectors averaged 6.0 ppm. The grower's average nitrogen use efficiency was 0.87 Ib-N/bu-grain while the sensor-based average 0.53 Ib-N/bu-grain. The average marginal net return increase (increase in partial profit by SBFM versus the grower sectors) average $53/acre for these four field sites. These results indicate that the sensor-based approach can maintain profitability while reducing the amount of groundwater residual nitrates over time.

References

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