EMERGING TRENDS FROM WISCONSIN'S NITROGEN OPTIMIZATION PILOT PROGRAM

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ABSTRACT

Accurately determining nitrogen (N) fertilizer requirements for crops is challenging due to the wide variability of landscapes and management across the state. Adjusting nitrogen rates comes with a high level of risk considering over-application can reduce profits and negatively affect water quality, while under-application can prevent yield targets from being reached. Conducting field-scale, on-farm research is a practical approach to better estimating optimum N rates on a field-by-field basis. In 2023, Wisconsin's Department of Agriculture, Trade, and Consumer Protection established the Nitrogen Optimization Pilot Program to provide funding for farmers to conduct their own N rate trials, in collaboration with UW-Madison. The program has supported 46 projects, conducting trials on 83 Wisconsin farms to address producer and partner driven research questions, ranging from evaluation of manure N credit to N need following a cover crop. Here, we explore trends in the dataset comparing in-season sampling with parameters of yield, economic and agronomic optimum nitrogen rate, and yield at 0 N. We also highlight the most interesting case studies to showcase how on-farm trials have shaped producer-driven decisions and demonstrate the potential of on-farm research to influence the future of nutrient management.

INTRODUCTION

Accurately predicting the N fertilizer needed for corn (*Zea mays* L.*)* during the growing season is an ongoing challenge in Wisconsin. Managing N fertilization effectively is critical to optimizing corn yield while minimizing environmental impacts and improving producer's bottom line. Current N recommendation tools provide an estimate of crop N need, but farm and field specific management may affect the accuracy of those estimates (Morris et al., 2018). Factors such as N source, timing, and placement coupled with other factors such as soil type, temperature and precipitation, and cropping history make it difficult to develop state or regional recommendations that are consistently reliable in the absence of long-term N rate trial data (Puntel et al., 2016). Winter rye (Secal cereale L.) is a commonly used cover crop due to its effectiveness in reducing soil erosion, scavenging nitrogen, and improving soil health, but can greatly impact nitrogen need for the subsequent crop. Understanding how cover crop management affects nitrogen dynamics is essential for effective nitrogen management in Wisconsin cropping systems.

To address these issues regarding N demand of crops in Wisconsin, replicated N rate studies were conducted on-farm under a variety of management conditions. Wisconsin's Department of Agriculture, Trade, and Consumer Protection established the Nitrogen Optimization Pilot Program (NOPP) to provide grants for farmers to conduct research projects aimed at answering specific N-related questions on their farms. Under 92.14(1 6), Stats., grant recipients shall collaborate with UW-Madison to implement a project that optimizes the application of commercial N and is carried out for at least two growing seasons. The objectives of these trials were to i) assess the value of early spring soil testing in accounting for available soil N, ii) to determine the economic and agronomic optimum N rate of corn, and iii) to determine the effect of a specific field variable (i.e., cover crops) on subsequent corn yield and optimum N rate.

MATERIALS AND METHODS

On-farm N rate trials were conducted across Wisconsin in 2023 and 2024. All trials in the program were N rate studies, with some including another management factor to create a split plot design (i.e. cover crop or biological product). Trials varied in project design based on the producers specific research question, field shape, and equipment capabilities, but at the basis consisted of a randomized complete block design with four replications. N rates were specific to each site with four to six rates in each trial ranging from 0 to well above grower standard rate. For each site, nitrogen response curves were chosen based on the best fitting model according to RMSE and adjusted R^2. The economic optimum nitrogen rate (EONR) was derived from the parameters of the best fitting model using a nitrogen to corn price ratio of 0.1.

Here, we highlight three sites in Lafayette County. These sites used a N rate trial (six rates) to explore N need of corn planted green following a rye cover crop. The experimental design was a randomized complete block, split plot design with four replications. The whole plot factor was a rye cover crop and the split plot factor was N rate. At all sites soil nitrate samples were collected pre-plant as a composite bulk sample of eight-twelve cores per block in cover and no cover treatment at a depth of 0-1' and 1-2'. Routine soil samples at a depth of 0-6" were also collected at this time. Cover crop biomass was collected in spring before termination to be analyzed for C:N. Yield was harvested and measured on a plot basis using a weigh wagon or yield monitor. Site 3 had a manure application of 12 ton/ac dry beef manure. Manure was spread on the growing cover crop in early spring.

RESULTS

Agronomic and economic optimum nitrogen rates had great variation from site to site across the state, with EONR varying from 0 to 193 lb-N/ac. The farmer "business as usual rate" is the N rate farmers would have applied to the trial area under normal conditions. Out of rate trials in 2023 and 2024, 19 sites did not reach a plateau within the nitrogen rates applied while 35 sites reached a peak or plateau within the applied rates.

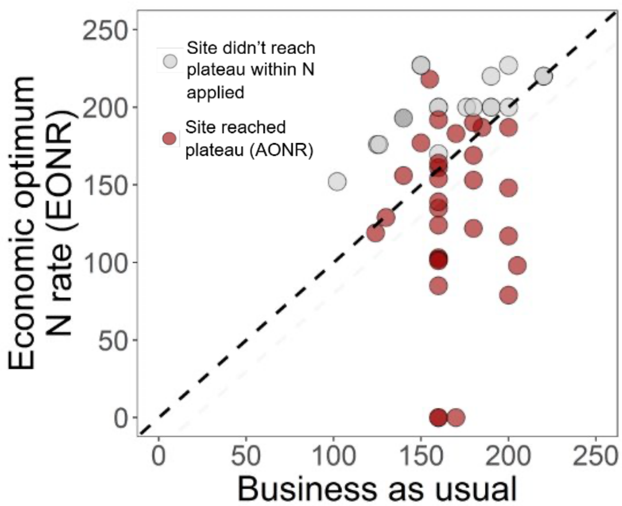

Figure 1. Economic optimum nitrogen rate (EONR) of nitrogen rate trials across the state by the farmer "business as usual" nitrogen rate in lb-N/ac. The black dashed line is the 1:1 line.

Cover crop trial- Site 1

Total biomass of the rye cover crop was 2355 22 and total nitrogen uptake of 48 lb/ac. The no cover control treatment had greater soil nitrate than the rye cover crop at both soil depths (Table 2), an indication of this nitrogen uptake by the cover crop. Quadratic plateau was the best fit curve for both the rye cover crop and no cover treatment. Corn yield was consistently lower following a cover crop than no cover, with the largest difference at lower N rates (Figure 3). EONR was 204 lb-N/ac following the cover crop and 179 lb-N/ac without cover.

Table 1. Pre-plant soil nitrate for all sites at the depth of 0-2'.

Pre-plant soil nitrate (NO_3-N)		
		lb/ac
Site 1	No cover	45
	Cover	15
Site 2	No cover	43
	Cover	18
Site 3	No cover	63
	Cover	20

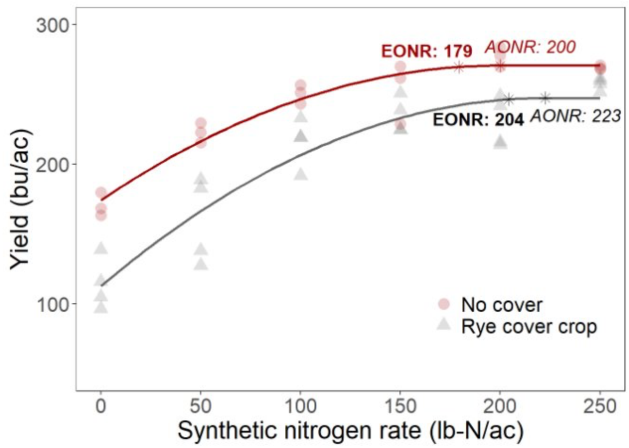

Figure 2. Site 1 quadratic plateau nitrogen rate yield response curve of corn following a cover crop treatment and bare control across six nitrogen rates. EONR was calculated using the parameters of the curve and a nitrogen to corn price ratio of 0.1.

Cover crop trial- Site 2

Total biomass of the rye cover crop was 967 lb/ac across the field, with a C:N of 15 and total nitrogen uptake of 26 lb/ac. The no cover control treatment had greater soil nitrate than the rye cover crop (Table 1), an indication of this nitrogen uptake by the cover crop. Quadratic was the best fit curve for both the rye cover crop and no cover treatment. Corn yield was consistently lower following a cover crop than no cover across all N rates (Figure 3). EONR was 236 lb-N/ac following the cover crop and was not reached within applied N rates following the rye cover crop.

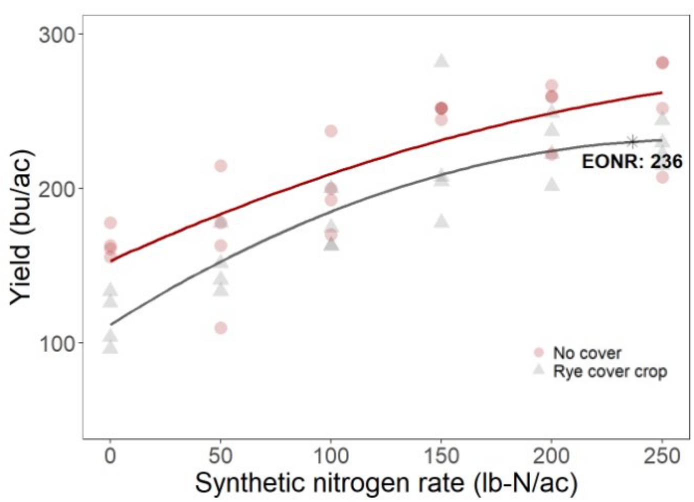

Figure 3. Site 2 quadratic nitrogen rate yield response curve of corn following a cover crop treatment and bare control across six nitrogen rates. EONR was calculated using the parameters of the curve and a nitrogen to corn price ratio of 0.1.

Cover crop trial- Site 3

Total biomass of the rye cover crop was 6275 lb/ac across the field, with a C:N of 18 and total nitrogen uptake of 168 lb/ac. The no cover control treatment had greater soil nitrate than the rye cover crop at both soil depths (Table 1), an indication of this nitrogen uptake by the cover crop. Corn yield was not significantly different at any N rate or between cover and no cover. This lack of response of yield to applied synthetic nitrogen indicated all necessary nitrogen was supplied to the field by the manure.

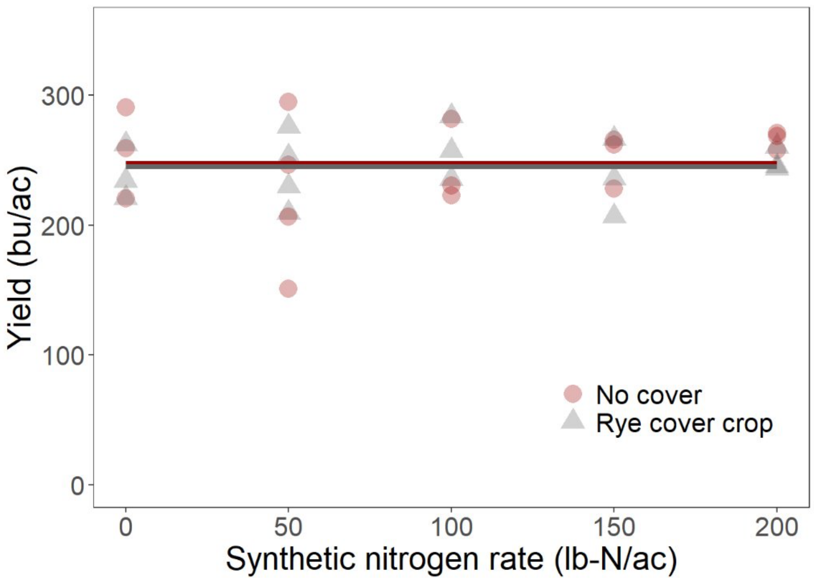

Figure 4. Site 3 yield of corn following a cover crop treatment and bare control across six nitrogen rates.

CONCLUSION

The cover crop case study demonstrates the importance of providing farmers with the tools to conduct their own trials to gain practical knowledge on nitrogen management on their farm. Rye successfully established as a cover crop on all sites and effectively scavenged soil nitrogen that may have otherwise been prone to leaching, but a yield drag occurred on two out of the three sites. Yield drag did not occur when the field had a manure application (site 3). Further research is necessary to better understand how cover crop management can be tweaked to avoid yield drag of corn following a rye cover crop.

Participating in on-farm nitrogen rate trials gave agronomic insight and provided value for both university researchers, farmers, and other project partners. Data generated from these on-farm studies has generated much interest from other local farmers as the data continues to be shared at field days and webinars. On-farm trials continue to highlight variability across the Wisconsin landscape and farming systems, proving the need for more local farmer generated data.

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