WISCONSIN'S NITROGEN OPTIMIZATION PILOT PROGRAM: HIGHLIGHTS AND SUCCESSES OF ON-FARM RESEARCH

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ABSTRACT

Accurately determining nitrogen (N) fertilizer requirements for crops is challenging due to the wide variability introduced by management practices and environmental conditions. Over-application reduces profits and negatively affects 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 (NOPP) to provide funding for farmers to conduct their own N rate trials, in collaboration with UW-Madison. So far, the program has supported 37 projects, conducting trials on 71 Wisconsin farms, which has led to valuable insights into management and region-specific N needs. These trials address producer and partner driven research questions, ranging from evaluating alternative N sources and timings, determining if optimum N rates varied by landscape position, and assessing the optimum N rate following a cover crop. Here, we highlighted 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 producers' 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 uncontrollable factors such as soil type, temperature, and precipitation, 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). To improve the precision and accuracy of future optimum N rate models, N rate studies need to be carried out on a variety of management and soil conditions.

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 to provide grants for farmers to conduct research projects aimed at answering specific N-related questions on their farms.

Under 92.14(16), 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., tillage, n-fixing product, cover crops, or zone management) on subsequent corn yield and optimum N rate.

MATERIALS AND METHODS

On-farm N rate trials were conducted in Wisconsin in 2023 across 33 counties. Here, we will focus on three of these trials that took place in Jefferson, Green, and Lafayette counties. Site 1 used an N rate trial to explore the N requirement of corn on two soil types. The experimental design was a randomized complete block design with six N rates and 4 replications in a low area of the field with finer textured soil and duplicated in a high area of the field with coarse textured soil. Site 2 used an 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. Site 2 used an N rate trial (eight rates) to explore a biological product that claims to fix N. The experimental design was a randomized complete block, split plot design with four replications. The whole plot factor was use of the biological product and the split plot factor was N rate.

At all sites, soil nitrate samples were collected pre-plant as a composite bulk sample of 8-12 cores per block at a depth of 0-1’ and 1-2’. Routine soil samples at a depth of 0-6” were also collected at this time. Site 2 collected cover crop biomass in fall before the first hard frost and in spring before termination to be analyzed for C:N. Yield was measured on a plot basis using a weigh wagon for sites 1 and 3 while a yield monitor was used for site 2. 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.

RESULTS

Site 1- Soil comparison

The fine textured field area had about 4% greater organic matter (Table 1) and greater preplant soil nitrate than the field with a coarse texture (Table 2). The coarse textured field reached EONR at 190 lb-N/ac while the response curve of fine textured field area did not plateau or reach EONR (Figure 1). Yield was consistently greater in the fine textured field area than the coarse across all N rates.

Table 1. Site 1 baseline soil analysis sampled pre-plant by field soil texture area at a depth of 0-6” prior to any nitrogen application.

	pH	OM	CEC	P	K	Ca	Mg

		%			- - - - - - - ppm - - - - - - -		
Coarse	7	1.9	8.7	77	129	1313	180
Fine	7.5	6.2	29	23	91	3920	665

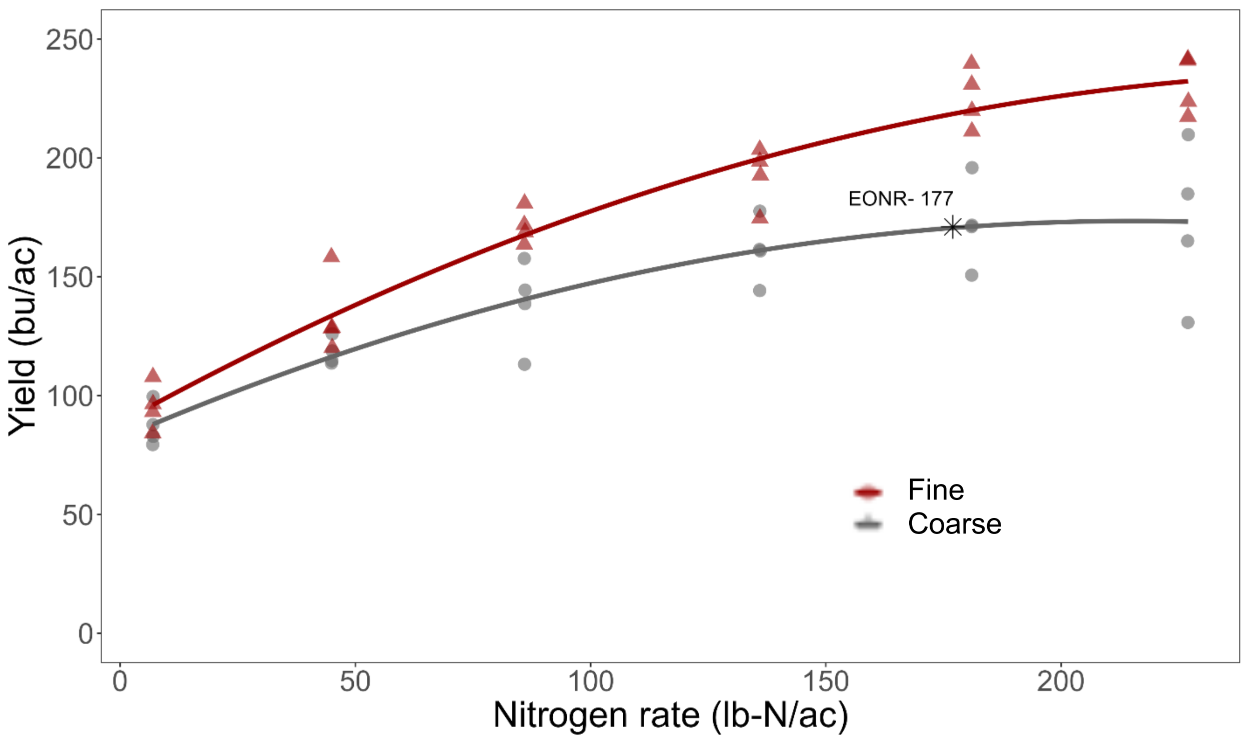

Figure 1. Quadratic nitrogen rate yield response curve of coarse and fine textured soil field area across six nitrogen rates. EONR was calculated using the parameters of the curve and a nitrogen to corn price ratio of 0.1.

Site 2- Biological product

Site 2 had the greatest soil nitrate of any of the sites, with nearly as much nitrate in the second foot as the first (Table 2). The use of the biological product did not lead to an increase of yield at any nitrogen rate. The quadratic curve was the best fit for both the control and biological treatment. In the biological treatment EONR was reached at 121 lb-N/ac while the control reached EONR at 124 lb-N/ac (Figure 2).

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

		Pre-plant soil nitrate (NO_3-N)		
		0-1'	1-2'	Total
		- - - - - -	lb/ac	- - - - - -
Site 1	Coarse	7.7	2.6	10.3
	Fine	29.4	12.4	41.8
Site 2	-	35.0	31.0	66.0
Site 3	Rye	8.9	6.1	15.0
	No cover	23.6	21.0	44.6

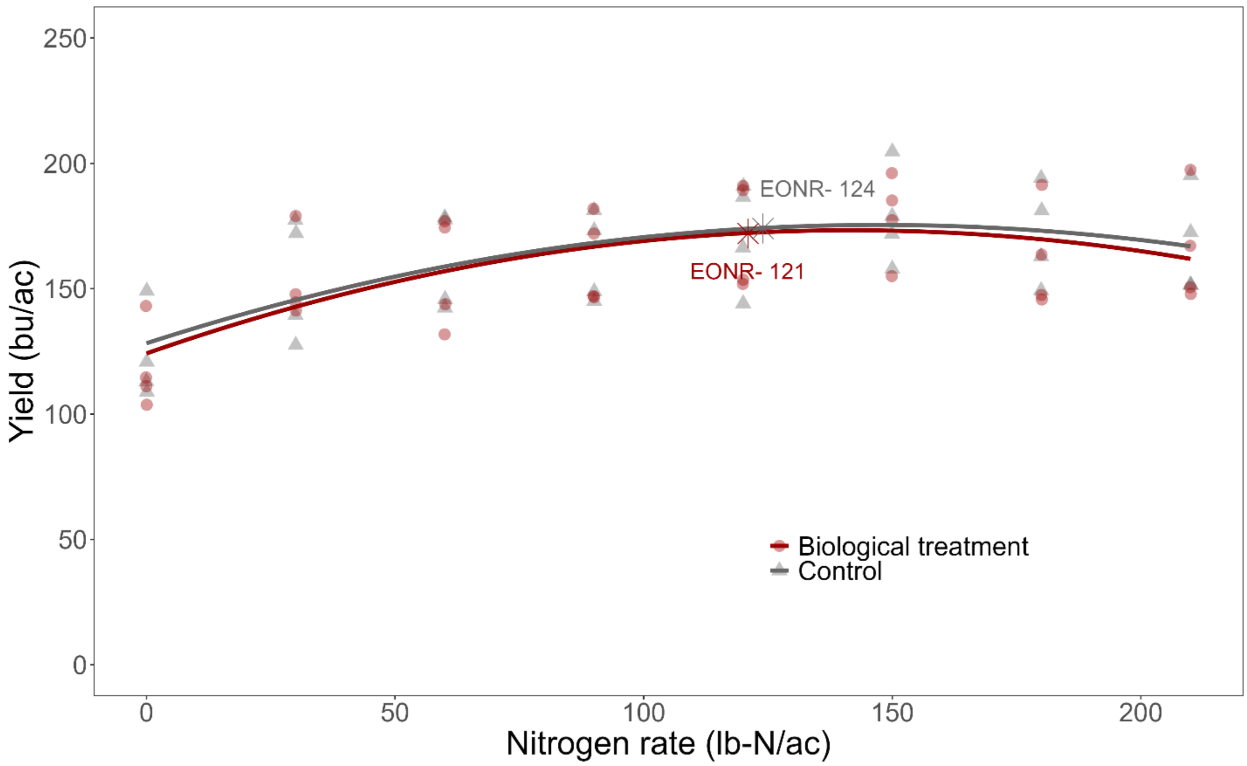

Figure 2. Quadratic nitrogen rate yield response curve of biological product treatment and control across eight nitrogen rates. EONR was calculated using the parameters of the curve and a nitrogen to corn price ratio of 0.1.

Site 3- Rye cover crop

Total biomass of the rye cover crop was 2355 lb/ac across the field, with a C:N of 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 the nitrogen uptake by the cover crop. Quadratic plateau was the best fit curve for both the rye cover crop and no cover control. Corn yield was consistently lower following a cover crop than no cover, with the largest difference at lower N rates (Figure 3). EONR was 182 lb-N/ac following the cover crop and 154 lb-N/ac without cover.

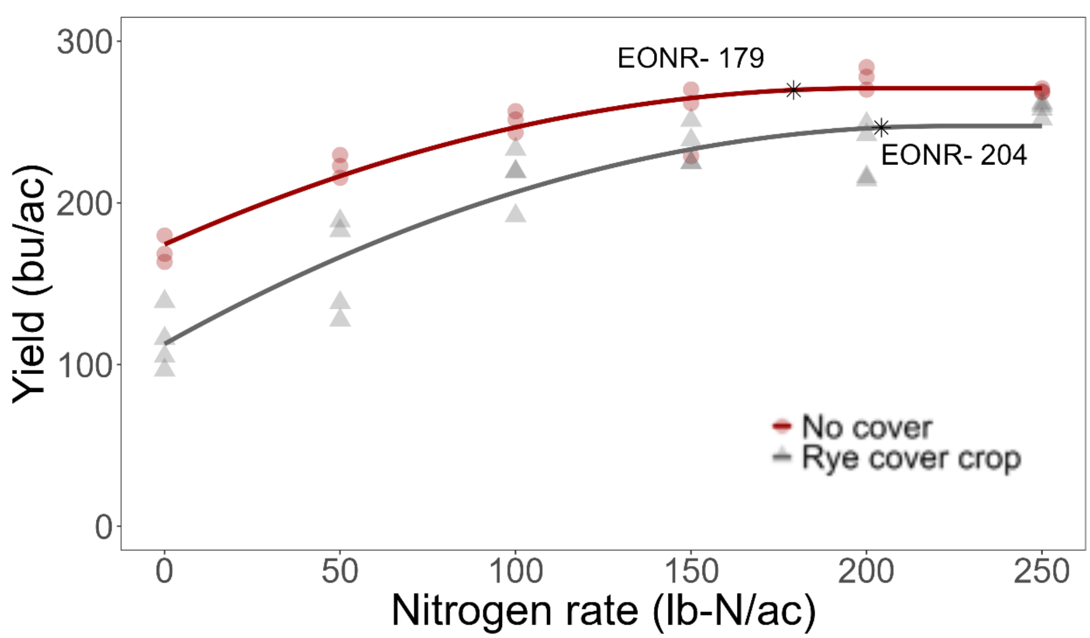

Figure 3. Quadratic plateau nitrogen rate yield response curve of corn following a cover crop treatment and bare control across six nitrogen rates. EONR was calculated using the parameters of the curve and a nitrogen to corn price ratio of 0.1.

CONCLUSION

The added field variables studied in each of these specific sites highlighted the importance of farm specific nitrogen rate studies. Site 1 demonstrated the importance of managing areas of the field separately, considering yield potential and nitrogen need may differ greatly based on soil variability. Site 2 proved the importance of testing the efficacy of nitrogen supplying products before making changes to nitrogen management or investing in products across the farm. Site 3 highlighted the benefit in rye as a cover crop in terms of scavenging nitrogen, but proved that some additional nitrogen is sometimes needed to maintain yields, and even then, yield loss may occur. All of these results are based on only one season of data, so management decisions should not be made until more data is accrued, although previous research in Wisconsin would support all of these findings.

These three case studies demonstrate the importance of providing farmers with the tools to conduct their own trials to gain practical knowledge on nitrogen management on their farm. Participating in on-farm nitrogen rate trials gave agronomic insight and provided value for university researchers, farmers, and other project partners. Data from these on-farm studies have generated interest from 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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