AN OVERVIEW OF ON-FARM NITROGEN RATE RESEARCH

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Abstract

Because crop advisors, farmers, and some in the fertilizer industry questioned the University's N recommendations as being too low and raised concerns that the N calibration research had been done primarily in small plots on University Experiment Station land, numerous N calibration studies for corn after soybeans were conducted on farmers' fields in southern Minnesota and northeastern Iowa from 1989 through 2002 to validate present N recommendations. On-farm replicated trials were conducted by University of Minnesota soil scientists at 13 small-plot sites and 13 field-size strip sites. In 2002, 39 unreplicated large strip trials (minimum of 5 acres/strip) were conducted by Center for Agricultural Partnerships (CAP) consultants and various cooperators in south-central Minnesota and northeastern Iowa. Nitrogen rates of 60, 90, 120, 150 lb N/A were applied at all 65 sites with many of the sites also receiving 0, 30, and 180 lb N/A. Regression analyses were conducted at each site and across appropriate pooled sites to determine the economic optimum N rate (EONR) and corn grain yield at the EONR (YEONR). The average EONR for the 13 small-plot sites was 86 lb N/A while the average EONR for the 13 field-sized strips was 100 lb N/A. YEONR's were 173 and 151 bu/A, respectively; the difference was due primarily to different site-years. The EONR was ≤ 90 lb N/A at 11 of the 26 sites and < 130 lb N/A at 22 sites. Plot size did not affect fertilizer N rate recommendations. Very high yields (YEONR averaging 174 bu/A in Minnesota and 194 bu/A in Iowa) were obtained in 2002 from the 39 sites in the CAP study. EONRs for the two states were 104 and 114 lb N/A, respectively, indicating that in years with favorable weather and growing conditions, very high yields can be obtained by following present University recommendations.

Introduction

More N is added for corn than any other nutrient in the Corn Belt. The right amount of N optimizes crop yield while minimizing loss of N to the environment. Applying too much N reduces profits to the farmer and can contribute to excess nitrogen leaching into ground or surface water through subsurface tile drainage.

Finding the right amount of fertilizer N to add for a crop means first estimating how much N is available from the soil and then adding fertilizer N to meet the crop's total N need. Because uncontrollable factors like precipitation and temperature affect the release of N from soil as well as the amount of N needed by a crop, the optimum amount of fertilizer N can change from location to location and from year to year. Continual studies measuring corn yield response to fertilizer N take these variations into account.

University agronomists and soil scientists have conducted hundreds of field studies to calibrate fertilizer N rates for corn since the 1960s. The N rate recommendations are often updated using the most recent corn hybrids with greater yield potential.

In recent years the University of Minnesota's N recommendations for corn have been questioned by the fertilizer industry and by some farmers and advisors. The recommendations were often considered to be lower than appropriate, with one reason being that many of the field studies were done on University Experiment Station land. From 1989 through 2001, University recommendations for corn after soybeans were tested in 29 experiments on farmers' fields to develop data for validating current recommendations and changing recommendations if needed. Best management practices were used at all sites and are considered essential for efficient N use.

Experimental Procedures

University Small-Plot Studies

Thirteen small-plot studies conducted from 1989 through 1999 were equally divided between the loess soils (silt loam) of southeastern Minnesota and the glacial till soils (clay loam) of south-central Minnesota. The small plots were 10 to 15 ft wide and 40 to 60 ft long and were replicated four to six times at each site. The farmers tilled, planted, applied pesticide, cultivated, and selected hybrid and planting rates. University scientists applied the fertilizer N, hand-harvested the yields, and collected other appropriate field data (weather, past cropping and nutrient history, etc.). Nitrogen was applied in 30-lb increments at rates from 0 to 180 lb/A at 7 sites and 0 to 150 lb/A at 6 sites. Urea was spring preplant-applied at 11 sites, and anhydrous ammonia was sidedressed at two sites. Further details can be found in Randall et al. (2003).

University Field-Size Strip Studies

Because some dealers, advisors, and farmers were not sure about the relevance of yield responses from small-plot studies, 13 field-size strip studies were conducted in 2000 and 2001. All sites were on glacial till soils in south-central Minnesota. Sites were chosen by the farmer and either local crop advisors, dealers, or state agency personnel. There was a concentration of sites in Nicollet County because of nitrate concerns in the St. Peter Wellhead area and the presence of a multi-agency project to examine N use for corn.

Spring or sidedress application was used at 10 sites and fall anhydrous ammonia plus N-Serve was used at 3 sites. Nitrogen was applied at rates of 0, 60, 90, 120, and 150 lb/A at 10 sites and included 180 lb N/A at three sites. Fertilizer N was applied by the dealer or farmer in strips matching the applicator width (30 to 60 ft). Strip length ranged from about 400 ft to more than 1200 ft.

At each field-strip site the tillage, planting, pesticide application, and hybrid and planting rate selection were done by the farmers. The strips were combine-harvested using yield monitors. All yield data were collected by the farmer and/or consultant. The strip-average yields were given to the authors of the publication (Randall et al., 2003) for statistical and economic analyses.

CAP Study

In 2002, a large study funded by the Center for Agricultural Partnerships (CAP) was conducted on 29 fields in southern Minnesota and 10 fields in northeastern Iowa. Nitrogen was applied by the grower or supplier in 30-lb increments ranging from 60 to 180 lb N/A. Control (0-lb) strips were included in some fields. Each strip was at least 200' wide and over 1500' long and was unreplicated within the field. All crop production practices (tillage, hybrid, population, herbicide, cultivation, harvesting, etc.) were uniform across all strips and were conducted by the farmer. All yields were determined by combines equipped with yield monitors and GPS. The data from each field were sent to Dr. David Mulla and Jose Hernandez (Precision Agricultural Center, Dept. of Soil, Water and Climate, University of Minnesota) to "clean" the data (remove outliers and harvest turn errors) and conduct statistical analyses for each site and across sites.

Statistical Evaluation

For the University's studies, a quadratic response plateau (QRP) model was fit to the yield data up to the N level where a yield plateau was reached. The economic optimum N rate (EONR) was calculated using an N price of $0.15/lb and a corn price of $2.00/bu to determine the N rate where the cost of an additional pound of fertilizer was no longer exceeded by the value of the additional yield response.

For the CAP study, a quadratic regression model was used to determine the EONR and corn grain yield at the EONR (YEONR). A N price of $0.17/lb and a corn price of $2.25/bu was used. Thus, the corn price: N price ratio (13.3) was the same for all studies.

Results and Discussion

University Small-Plot Studies

The EONR for each of the 13 small-plot sites ranged from a low of 0 to a high of 140 lb N/A (Figure 1). The EONR averaged across the 13 sites was 86 lb N/A while the YEONR was 173 bu/A.

The optimum N rate data in Fig. 1 also show the variability among sites. University scientists usually set their recommendations slightly higher than the response data suggest. This cushions the farmer from risk of yield and profit loss under unforeseen conditions. In this case, a N recommendation of 120 lb N/A was actually more than was needed for optimum yields at 10 of 13 sites. Based on these yield responses to N in small-plot studies, the 120-lb N rate, recommended by the University of Minnesota for 150 to 174 bu/A corn grown on these soils, was enough to optimize yield and profit at 10 of 13 sites. In fact, the yield maximum at 7 of 13 sites was reached at less than 90 lb N/A.

University Field-Size Strip Studies

The EONR ranged from 55 to 169 lb N/A and averaged 100 lb N/A for the 13 field-size strip studies (Figure 2). The YEONR was 151 bu/A. As with the small-plot studies, these field-size experiments demonstrate the site-to-site variability when finding an optimum N rate for corn. But in total, a 120-lb N rate was enough to optimize corn yield and profit at 11 of 13 sites. On 4 sites, yield and profit were maximized at N rates of 90 lb N/A and less.

Small Plot vs. Field-Size Strips

Corn yields for the 0, 60, 90, 120, and 150-lb N rates were pooled for all 13 small-plot studies to find the EONR for all 13 sites. The same yield pooling procedure was used to find the EONR for all 13 field-size studies. Although the procedures were different for these two types of field studies, the results were remarkably similar (Figure 3). EONR's for the small plots and field-size strips were 105 and 99 lb N/A, respectively. The YEONR was greater in the small plots (173 bu/A) than in the field-size strips (151 bu/A) due to very high yields in the small plots in southeastern Minnesota in 1989, 1998, and 1999 when field-size strip studies were not done. This shows that plot size used in N rate calibration trials does not affect fertilizer N rate recommendations.

CAP Study

The EONR across the pooled yield data from 29 fields in south-central Minnesota was 121 lb N/A (Figure 4). Additionally the YEONR was 174 bu/A, and the yield at the 0-lb N rate was 135 bu/A. The average EONR across the 29 fields was 104 lb N/A with the frequency distribution shown in Table 1. Eighty six percent of the sites had an EONR of 130 lb N/A or less and 41% had an EONR of 90 lb N/A or less.

In northeastern Iowa, the average EONR across the 10 fields was 114 bu/A with an YEONR of 194 bu/A. The frequency distribution shown in Table 1 indicates an EONR of 130 lb N/A or less occurred in 90 % of the sites.

These findings clearly show that very high corn yields can be and often are obtained with N rates currently being recommended by Universities. In those years when temperature, sunlight, and precipitation are conducive for very high yields, soil N availability is also increased. Thus, more fertilizer N is not usually needed to produce greater-than-normal yields.

Conclusions

This paper presents the results of 26 site-years of on-farm N rate calibration research conducted by University soil scientists in Southern Minnesota and N validation trials conducted on 39 farmer's fields in south-central Minnesota and northeastern Iowa in 2002 by a private partnership. The primary conclusions were:

- The EONRs averaged across 13 small-plot sites and 13 field-size strip sites were 86 and 100 lb N/A, respectively. When the yield data were pooled for the 13 small-plot sites and for the 13 field-size strip sites, the EONRs were 105 and 99 lb/A, respectively. Yields produced at these EONRs were 173 and 151 bu/A, respectively.
- Although yield variability among the 26 sites was significant, it was not nearly as dramatic as the variability among EONRs across the sites. EONR ranged from 0 to 140 lb N/A in the small plots and from 55 to 169 lb/A in the field-size strips.
- Plot size used in N rate calibration research did NOT affect fertilizer N rate recommendations.
- The average EONRs across the 29 Minnesota fields and 10 Iowa fields in 2002 were 104 and 114 lb N/A, respectively with grain yields averaging 184 and 194 bu/A at the EONR rates. Eighty six percent of the Minnesota fields and 90% of the Iowa fields had an EONR of 130 lb N/A or less.

- The N rate recommended by the University of Minnesota achieves optimum corn yield and may be greater than needed for maximum profitability in many fields.

References

Randall, Gyles. Michael Schmitt, Jeffrey Strock, and John Lamb. 2003. Validating N rates for corn on farm fields in southern Minnesota. Univ. Minnesota Ext. Serv. BU-07936.

Acknowledgement

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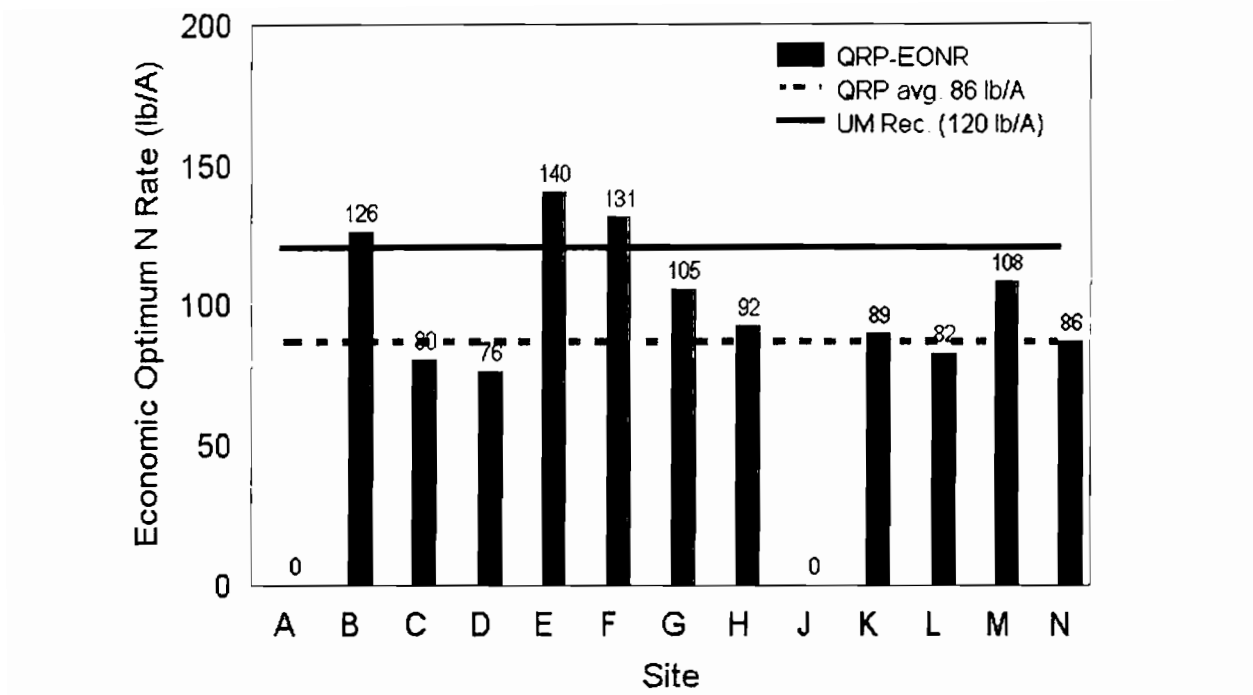

Fig. 1. Economical optimum N rate (EONR) for 13 small-plot sites in farmer's fields in southern Minnesota.

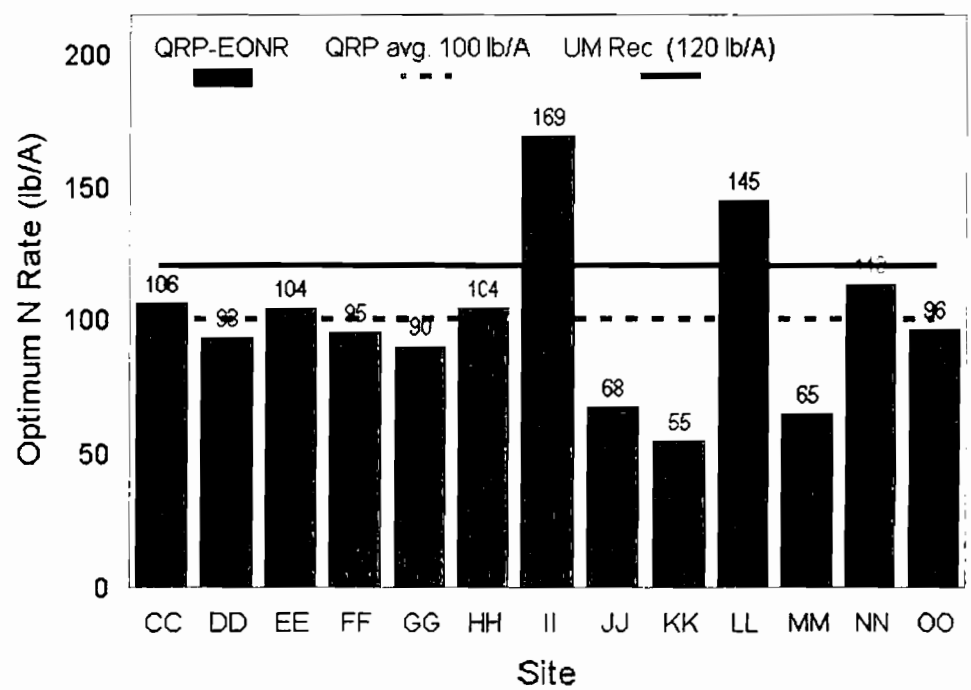

Fig. 2. Economic optimum N rate (EONR) for 13 field-size strip studies on farmer's fields in south-central Minnesota.

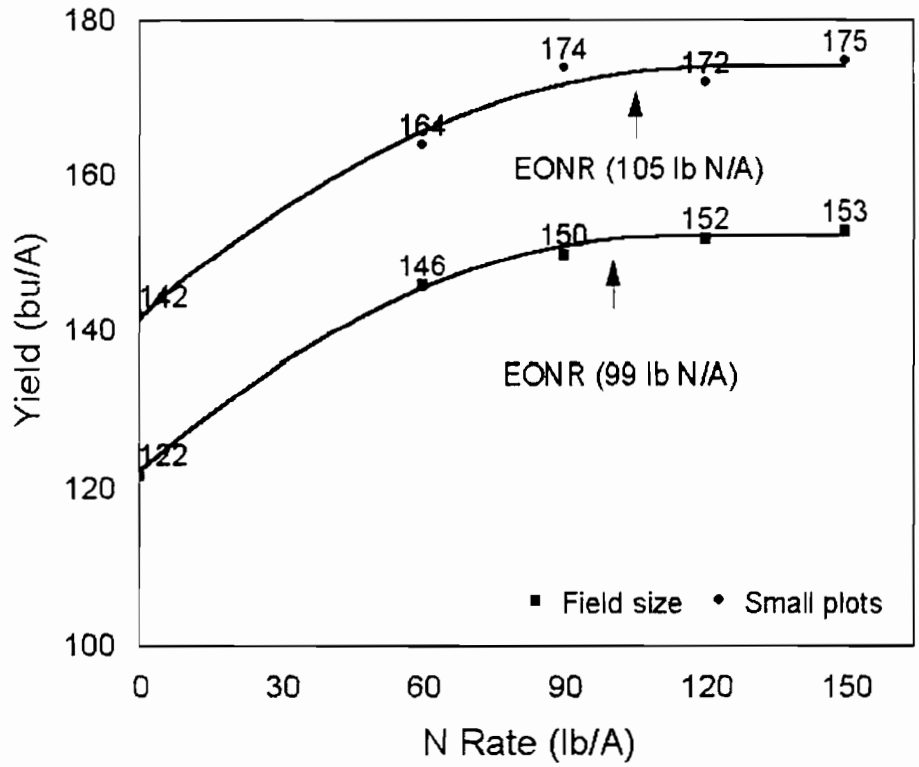

Fig. 3. Effect of fertilizer N rate on average corn yield and EONR from 13 small-plot and 13 field-size strip studies in Minnesota.

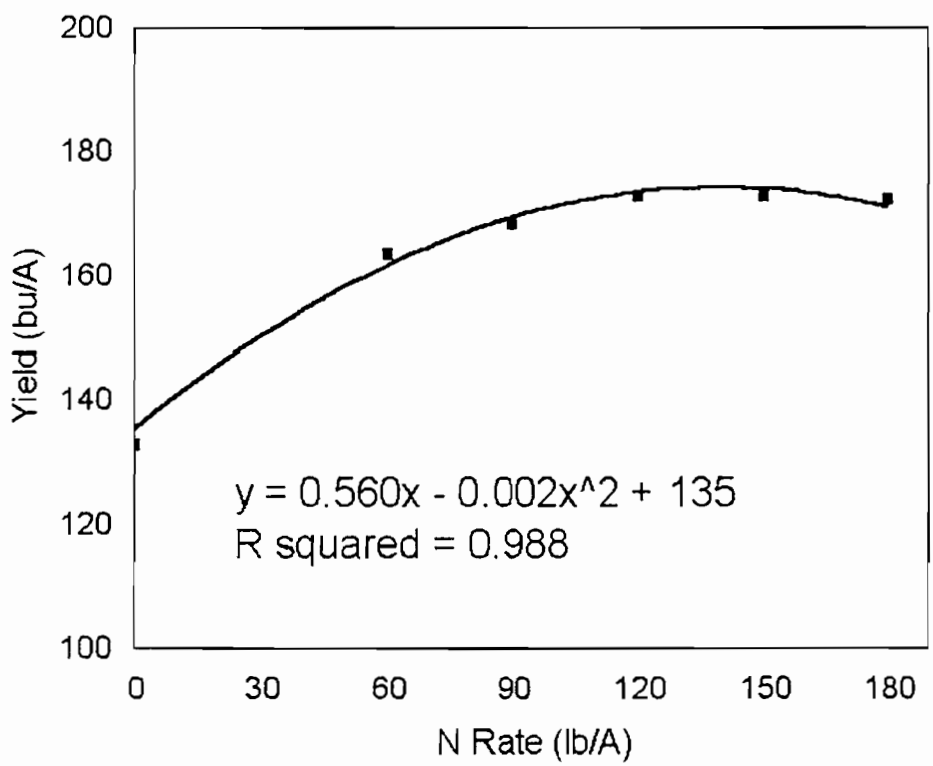

Fig. 4. Effect of fertilizer N rate on the average grain yield pooled from 29 sites in south-central Minnesota in 2002.

Table 1. Frequency distribution of EONRs across the 29 Minnesota sites and the 10 Iowa sites in the CAP supported project in 2002.

EONR Frequency Class	State	
	Minnesota	Iowa
lb N/A	%	
0-10	0	0
11-30	3	0
31-50	7	0
51-70	17	0
71-90	14	20
91-110	14	50
111-130	31	20
131-150	11	10
151-170	0	0
171-190	3	0

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