Can we reduce nitrogen applications to corn?

# Cooperators:

* Amundsons (Osage, IA)
* Anderson (Aurelia, IA)
* Bakehouse (Hastings, IA)
* Bardole (Jefferson, IA)
* Bennett (Galva, IA)
* Borchardt (Fenton, IA)
* Boyer (Reinbeck, IA)
* Deal (Jefferson, IA)
* Dooley (Albion, IA)
* Frederick (Jefferson, IA)
* Fredericks (Osage, IA)
* Harvey (Redfield, IA)
* Prevo (Bloomfield, IA)
* Sieren (Keota, IA)
* Veenstra (Grinnel, IA)
* Waldo (Cascade, IA)

PHOTO/Image

Map of participant locations?

Caption: XX.

Year: 2022

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Funding: XX

# In a Nutshell:

* Farmer cooperators performed 17 replicated strip trials testing their typical nitrogen rate against that rate reduced by 15-45%
* Key Findings
  + All sites experienced drier-than-average growing seasons
  + 12 of the 17 trials saw potential for financial savings when reducing their N rates

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# Background

In XXX Practical Farmers of Iowa (PFI) formally established the Cooperators’ Program, which continues to be a hallmark of PFI programming. Many farmers at that time wanted to know if they were applying too much nitrogen (N) fertilizer to their corn crops – the newly minted Cooperators’ Program provided the framework for farmers to scientifically answer this question. From 1988-1993 cooperators conducted 57 trials that compared corn yields and financial outcomes at their typical nitrogen (N) fertilizer rate with those at a reduced N rate of their choosing. Across sites, the average difference between typical and reduced rates was 56 units of N per acre, corresponding to a XX% reduction. In 88% of those trials (50 of the 57), the cooperators found they could save money by applying the lower N rate. Is this true? Were financials part of the original design? Or can I assume this based on the lack of yield reduction? Thirty years later, farmers are again interrogating their N rates. In this round, farmers are wondering if the soil health-building practices they’ve implemented (reduced tillage, cover crops, diversified rotations, etc.) will allow them to reduce their typical N rates.

This newest round of N trials began in fall 2021 in preparation for the 2022 growing season. The first year included farmers recruited by PFI staff who self-identified as using soil health-promoting practices for at least five years. Using a replicated strip-trial design, farmers compare yields and finances at their usual N rate with those observed at a reduced rate. Based on the trials conducted 30 years ago, PFI staff suggested farmers try reducing their N application by 50 pounds of N per acre. While this is an aggressive reduction in many systems, one goal of the trial was to push farmers to explore N rates outside of their comfort zone.

If cooperators can maintain corn yields and/or save money at the reduced N rate, results might spark confidence to reduce (or at least question) fertilizer rates going forward, much like what happened for the original cohort of farmers who trialed fertilizer rates. If the reduced N rate lowers corn yields and loses money, cooperators will still have gained valuable information: They can be more confident that their typical rate is the right rate for their farm, but maybe new long-term practices could help reduce it in the future.

# Methods

### Weather

Each cooperator chose a US Census-recognized town with which to associate the trial. The latitude and longitude of the chosen town were used to retrieve weather data from the National Aeronautics and Space Administration (NASA) Prediction of Worldwide Energy Resources (POWER) project (<https://power.larc.nasa.gov/>) using the *nasapower* package [1] for R software [2]. Data was downloaded for the period spanning January 1, 1992 through December 31, 2022. Two weather variables were used: (1) cumulative daily precipitation values and (2) the average daily air temperature at two meters above ground level. The weather data was separated into two data sets: one comprising the entire 30 years of data (historical weather data), and one containing only data from January 1 – December 31, 2022 (trial year data).

To provide context for each trial’s temperatures, the historical mean temperature for month at a given site was calculated using the historical weather dataset. The historical value was subtracted from the trial year average temperature for that month to provide an estimate of the deviation from average conditions. For example, in Galva Iowa the historical average temperature in April is 48 deg F. In 2022, the month of April had an average temperature of 44 deg F, resulting in a deviation of -4 deg F (cooler than average). To provide context for precipitation, the cumulative precipitation up to a given day was calculated for each year separately. The historical value was calculated as the average cumulative precipitation received up to a given calendar day. Like the temperature deviation calculation, this historical mean was subtracted from the cumulative precipitation for each calendar day in 2022. Continuing with the Galva Iowa example, Galva historically receives an average of 11 inches of precipitation from January 1 through June 1. In 2022, Galva had received 10.6 inches, for a deviation of -0.4 inches (drier than average).

### Yields

At each trial, differences in yields between treatments were assessed for statistical significance using a statistical model that tested for the effect of the N treatment while accounting for any natural yield gradients in the field. Significance was assessed at a 95% confidence level, meaning if each trial were repeated 100 times, we would expect 95 instances to give the same result.

### Finances

Nitrogen (N) prices depend on several factors including the form of N, the timing of the purchase, and the location of the purchase. Similarly, the price received for corn fluctuates throughout the year. Due to this variation, as well as the limited control producers have over the price paid for N and the price received for corn, we explored three price scenarios to compare the typical and reduced N treatments: best-case savings, midpoint savings, and worst-case savings (**Table 1**). In the 2021/2022 suite of trials, farmer cooperators reported nitrogen prices ranging from $0.60/lb N up to $1.20/lb N. Not all farmers reported the price received for corn, so we used USDA National Agricultural Statistics Service (NASS) [3] data as reported by Iowa State University’s Ag Decision Maker (<https://www.extension.iastate.edu/agdm/crops/pdf/a2-11.pdf>), providing a range in prices received for corn in Iowa for the year 2022.

**Table 1. Summary of financial scenarios**

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | Description | N cost | Corn price received |
| Best-case savings | Expensive N, low corn revenue | $1.20/lb N | $5.70/bu |
| Midpoint savings | Midpoint N, midpoint corn revenue | $0.90/lb N | $6.59/bu |
| Worse-case savings | Cheap N, high corn revenue | $0.60/lb N | $7.48/bu |

A partial budget was performed for each replicate of each trial as described below. For each N treatment, the amount of N applied was multiplied by the assumed price paid. The corn yields at 15.5% moisture were multiplied by the assumed price received per bushel. For each replicate, the net profit for the typical N treatment was subtracted from the reduced N treatment. Therefore, a positive value represents a financial savings at the reduced N rate. This process was done for each of the three price scenarios.

To assess the significance of treatments on finances, one-sample t-test was used to assess whether the financial outcome in each scenario was significantly different from $0 per ac at 95% confidence levels.

To account for the varying amounts of reductions each cooperator chose, for visualizations the savings per acre were normalized by the difference between the N applied at the typical and reduced rates, producing a savings per unit N reduction per acre (with negative savings indicating a financial loss).

# Results and Discussion

### Treatments

Sixteen producers conducted a total of 17 independent N trials. The chosen treatments reflected the variety of cooperator farming systems, with typical N rates ranging from 108-264 lb N/ac, and reduced N rates ranging from 59-200 lb N/ac (**Figure 1**). When averaged over all of the trials, typical and reduced N rate treatments were 175 lb N/ac and 124 lb N/ac, respectively.

Chart, histogram

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**Figure 1. Seventeen trials tested two nitrogen (N) application treatments in the 2022 growing season. A cooperator’s typical N rate (dark green bar), chosen reduced N rate (light green bar), and the reduction relative to the typical rate (white text).**

### Weather

All 17 trials saw a very cool April, followed by a warm and progressively drier growing season (**Figure 2**).

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**Figure 2. Individual cooperator site weather compared to 30-year historical averages for that site. (Left) Average monthly air temperature deviations and (right) cumulative precipitation deviations.**

Overall, although all sites experienced a hot and dry growing season, the diversity in N application amounts, sources, methods, and timing as well as cropping system history contributed to varied outcomes for each cooperator.

### Finances

The financial outcomes of reducing N varied by trial (**Figure 3**). Five of the 17 trials (29%) saw statistically significant financial losses under all price scenarios, three trials (18%) saw statistically significant financial gains in all price scenarios, and the remaining nine trials (53%) had outcomes that were sensitive to the price scenarios.

A picture containing graphical user interface

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**Figure 3. Financial impacts of reducing nitrogen rates under a range of price scenarios. Best-case (top of vertical bar), worst-case (bottom of bar) and midpoint 2022 price scenarios (white points), with blue bars indicating a statistically significant (95% confidence level) financial advantage in all scenarios, tan bars indicating outcomes were sensitive to price scenarios, and orange bars indicating a statistically significant financial loss in all scenarios. The x-axis labels present each cooperator’s family name and the amount they reduced their typical N rate to achieve the reduced N treatment (see Figure 2).**

### Yields

Eleven of the 17 trials (65%) saw statistically significant reductions in corn yields at the reduced N rate. However, it is worth noting statistical significance is not related to financial outcomes (**Figure 4**). Statistical significance is a function of both the magnitude of the difference in treatments, as well as how variable the yields in the field were. It helps readers and cooperators decide how much to ‘trust’ the yield changes, which can help with fine-tuning future N management decisions. For example, Nathan Anderson saw a statistically significant decline in yields by 3 bu/ac at the reduced N rate (**Figure 4**). While he can be confident that reduction was real, he also saw a statistically significant financial savings (**Figure 3**). For comparison, Sam Bennett saw a similar reduction in yields, but the reduction was not statistically significant so he should question how ‘real’ the reduction was. However, Sam still saw a significant financial savings at the reduced N rate.

Chart

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**Figure 5. Change in corn yield (bars) and financial outcomes (text) with reduced nitrogen (N) application. The y-axis shows the cooperator family name with amount of N reduced, orange indicates a trial with a significant financial loss at the reduced N rate, dark blue represents trials showing a significant financial savings (see Figure 4 for financial scenarios).**

### Nitrogen used per bushel of corn

I don’t actually think this is a very useful metric in this context. The interpretation is highly dependent on what the ‘assumed’ N-response curve looks like. And the N-response curve changes a lot. It may have been almost flat in such a dry year.

# Appendix A. Rachel and Alec Amundson, Osage IA

“[We] had some understanding of how to cut N when planting into clover,

this was a great way to verify our thinking.”

The financial outcome showed **potential savings**. A 49 lb N/ac reduction was too large this year, but there is potential for financial savings with a smaller reduction.

**Figure A1. Summary of trial results**

Graphical user interface, chart

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*Historical cropping system (5 year):* Strip-till, corn, soybeans, rye cover crop

*Previous crop:*  Oats/red clover cover crop

Replications and plot size: 4 reps, 1.7 acres per rep

*Corn planting/harvest date:*  May 14, 2022/October 23, 2022

Corn row spacing/planting density: 30 inch; 33,000 sd/ac

*Nitrogen sources and application timing:* Chemical sources; fall, spring, and side-dress

# Appendix B. Nathan Anderson, Aurelia IA

“I hope my research site, combined with other farmer-cooperator sites…can reform the narrative around nitrogen fertilization and use for the benefit of farmers and the environment.”

The financial outcome showed **savings**. A 53 lb N/ac reduction saved money this year, but this was likely influenced by the drought which rendered yields less responsive to N.

**Figure B1. Summary of trial results**

Graphical user interface, chart

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Historical cropping system (5 year): Corn, soybeans, rye cover crops

Previous crop: Corn

Replications and plot size: 4 reps, 2.11 acres per rep

*Corn planting/harvest date:*  May 19, 2022/October 14, 2022

Corn row spacing/planting density: 30 inch; 35,500 sd/ac

*Nitrogen sources and application timing:* Turkey litter, chemical; winter, at planting, side-dress

# Appendix C. Jon Bakehouse, Hastings IA

“[These trials will] give me confidence to either reduce N rates or be secure in the knowledge we aren’t over-applying nutrients”

The financial outcome showed **potential savings**. A 56 lb N/ac reduction was too large this year, but there is potential for financial savings with a smaller reduction.

**Figure B1. Summary of trial results**

Chart

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Historical cropping system (5 year): Corn, soybeans

Previous crop: Soybeans

Replications and plot size: 4 reps, 0.8 acres per rep

*Corn planting/harvest date:*  May 11, 2022/September 29, 2022

Corn row spacing/planting density: 30 inch; 34,000 sd/ac

Nitrogen sources and application timing: Chemical; Spring, side-dress

Appendix D. Pete Bardole, Jefferson IA

“I thought the yield reduction would be higher”

# Appendix E. Sam Bennett, Galva IA

“I knew we could grow good corn with less N, but knowing what happens when corn runs out of N, I habitually over apply fertilizer. This trial helped give me the confidence to take a deeper look at what rates I'm planning to apply.”

“This trial will put together a good set of farm-scale data to give farmers the confidence to dial in their N rate to improve profitability and water quality.”

“Most farmers don't have the confidence or data to try to reduce fertilizer rates and see what happens. We get one shot at the best crop every year, and the logical thing to do seems to be to give the crop everything it needs (and more) to maximize yields. “

Appendix F. Vaughn Borchardt, Fenton IA

**“**Probably should've had an additional 20# check.”

# Appendix G. Jack Boyer, Reinbeck IA

When asked what was the most valuable aspect of conducting this trial, Jack replied simply: “Cost reduction.”

# Appendix H. Chris Deal, Jefferson IA

“One of my biggest questions for several years has been whether I was being too aggressive with the amount of N I was using. This trial allowed me to explore that important question.”

“This was 1 trial on 1 farm for 1 year. The real value comes by increasing the "n" (i.e. number of samples) for these trials. If they can become regionalized, that would be great as well. Our soil in Greene County is certainly different from the soils in different parts of the state.”

# Appendix I. Wade Dooley, Albion IA

**“**Need to continue testing the hypothesis, perhaps at lower ratios of difference.

# Appendix J. Bill Frederick, Jefferson IA

If it works it will greatly reduce N cost and increase profitability.

My search for optimum N rates isn't over yet.

# Appendix K. Wayne Fredericks, Osage IA

# Appendix L. Robert Harvey, Redfield IA

I'm hoping to involve my daughter and use this experience as an opportunity to interest her in the farm operation.

# Appendix M. Kevin Prevo, Bloomfield IA

While Kevin wanted to help others, he “gained knowledge and had fun!”

# Appendix N. Tim Sieran, Keota IA

I've already got N rates cut to the bone, so this trial had little impact on my practices

# Appendix O. Kevin Veenstra, Grinnell IA

Without this trial, Kevin may have cut back nitrogen too much too soon.

# Appendix P. Marissa Waldo, Cascade IA

Oftentimes, side-dressing is just assumed to be necessary for an in-season N supply. It was eye-opening to see no significant yield difference.  
between manure-only and manure + side dressing.

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Appendix

Figure of Galva temperature and cumulative precipitation deviation calculations