**MiCan we reduce nitrogen applications to corn?**

# Cooperators:

* Amundson (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

PFI Contact: Stefan Gailans, (515) 232-5661, stefan@practicalfarmers.org

Funding: XX

# In a Nutshell:

* Farmer cooperators performed 17 replicated strip trials testing their typical nitrogen rate against that rate reduced by 20-74 lb N/ac
* Key Findings

Make it on a percentage reduction

* + Cooperators’ typical rates ranged from 108–264 lb N/ac
  + Relative reductions for the reduced N rate treatment ranged from 15% to 45%
  + All sites experienced cool and dry early season weather conditions
  + XX of the 17 trials saw a financial savings at the reduced N rate under average price scenarios

**PHOTO**

**X**

**Caption:** XX

# Background

XX

# Methods

### Weather

Each cooperator chose a US Census-recognized town/city with which to associate the trial. The latitude and longitude of the chosen town/city 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 data. 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 by June 1. In 2022, it 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 nitrogen 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.

### Nitrogen applied per bushel of corn yield

At each trial, differences in the amount of nitrogen applied per bushel of corn yielded for each treatment were assessed for statistical significance using the same statistical modeling approach and levels of confidence as were used for yields.

### 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. Since producers often have limited control 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, average savings, and worst-case savings (**Table 1**). In this 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 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. For each N treatment, the amount of nitrogen applied was multiplied by the assumed price paid. The corn yields at 15.5% moisture were multiplied by the assumed price received. 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 price scenario.

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/ac at 95% confidence levels.

To account for the varying amounts of reductions each cooperator chose, the savings were normalized by the difference between the N applied at the typical and reduced rates and presented as the change in dollars per acre per pound of N reduced when reducing N rates.

# Results and Discussion

### Weather

All 17 trials saw a very cool April, followed by a warmer and dry growing season (**Figure 1**).

Chart, line chart

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**Figure 1. 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.

### Treatments

Typical and reduced N rate treatments averaged 175 lb N/ac and 124 lb N/ac, respectively. However, the chosen treatments varied widely by cooperator, with typical N rates ranging from 108-264 lb N/ac, and reduced N rates ranging from 59-200 lb N/ac (**Figure 2**).

Chart, histogram

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**Figure 2. Two nitrogen (N) application treatments were tested in this project. A cooperator’s typical N rate (dark green bar) and a reduced N rate (light green bar), with a range of resulting relative reductions (percentages above bars).**

### Finances

The financial outcomes of reducing N varied by trial (**Figure 4**). Five of the trials (xx%) saw statistically significant financial losses under all price scenarios, three trials (xx%) saw statistically significant financial gains in all price scenarios, and the remaining nine trials (x%) had outcomes that were sensitive to the price scenarios.

Chart

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**Figure 4. 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 name and the amount they reduced their typical N rate to achieve the reduced N treatment (see Figure X).**

### Yields

Eleven of the 17 trials (65%) saw statistically significant reductions in corn yields at the reduced N rate (**Figure 5**). These significant yield reductions ranged from 3 bu/ac (Anderson) to 49 bu/ac (Harvey).

However, it is worth noting that 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 is not indicative of financial outcomes. The statistical significance of yield differences helps cooperators decide how much to ‘trust’ the yield values, which can help with fine-tuning future N management decisions. For example, while Anderson saw a statistically significant decline in yields at the reduced N rate (**Figure 5**), he also saw a statistically significant financial savings (**Figure 4**).

**Chart

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**Figure 5. Change in corn yield (bars) and financial outcomes (text) with reduced nitrogen (N) application. N rates were reduced by 20-74 lb N/ac (15-45%), 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

Need to think about this. N rate is at the point of breaking when bushels/kg N doesn’t change when N is reduced

**Figure 6. Green points represent the mean amount of nitrogen (N) applied per bushel of corn produced at the ‘typical’ N rate for a given trial, arrow tips represent the mean value at the ‘reduced’ N rate when a significant change occurred.**

Say more things

# 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.”*

General cropping system: No-till, corn and soybeans with rye and clover joi….

Previous crop: Oats/red clover cover crop

Replications and plot size: 4 reps, XX

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

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

Typical rate: 130 lb N/ac (fall, spring, and side-dress)

Reduced rate: 80 lb N/ac (fall, spring, and side-dress??)

Result: 50 was too much, but there is potential for a reduction

Chart, line chart

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**Figure A1. Weather in Osage, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

Chart, histogram

Description automatically generatedInclude the bar showing the fertilizer

**Figure A2. Results from the Amundsons’ replicated trial.**

# 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.”

## Background

Previous crop: Corn/cereal rye cover crop

Replications and plot size: 4 reps, 2.11 acres/strip

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

Corn row spacing and seeding rate: 30 inch, 35,500 sd/ac

Typical rate: 157 lb N/ac (turkey litter, UAN+ATS, UAN sidedress)

Reduced rate: 105 lb N/ac (turkey litter, UAN+ATS)

Chart, histogram

Description automatically generated**Figure B1. Weather in Aurelia, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

*“In a drought year, I expected there to be a lower response to additional nitrogen, but didn't expect the final results to be so close.”*

Chart

Description automatically generated**Figure B2. Results from Nathan Anderson’s replicated trial.**

# 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”

## Background

**Chart, line chart, histogram

Description automatically generatedFigure C1. Weather in Hastings IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

Chart, histogram

Description automatically generated

Jon normally wouldn’t have tried reducing his N rate by such an aggressive amount, but it showed him the yield decline wasn’t as large as he was expecting.

**Figure C2. Results from Jon Bakehouse’s replicated trial.**

**Appendix D. Pete Bardole, Jefferson IA**

“I thought the yield reduction would be higher”

## Weather

**Figure D1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

Like other cooperator sites, xx saw a cool and dry spring. Starting around June conditions were back to average temperatures and the cumulative precipitation trended higher than the historical average. Overall, in 2022 xx IA had ~x more inches of precipitation compared to the historical average (xx inches).

## Results

**Figure D2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# 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. “

## Weather

**Figure E1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

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## Results

**Figure E2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

**Appendix F. Vaughn Borchardt, Fenton IA**

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

## Weather

**Figure F1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

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## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# Appendix G. Jack Boyer, Reinbeck IA

**“**What was the most valuable aspect of conducting this trial, for you? Cost reduction.”

## Weather

**Figure G1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

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## Results

**Figure G2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# 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.”

## Weather

**Figure H1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

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## Results

**Figure H2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# Appendix I. Wade Dooley, Albion IA

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

## Weather

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Like other cooperator sites, xx saw a cool and dry spring. Starting around June conditions were back to average temperatures and the cumulative precipitation trended higher than the historical average. Overall, in 2022 xx IA had ~x more inches of precipitation compared to the historical average (xx inches).

## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# 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.

## Weather

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## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# Appendix K. Wayne Fredericks, Osage IA

## Weather

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## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# 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

I have drifted away from on-farm trials and need to be doing more. I was scouting fields more often looking for signs of fertilizer rate reductions besides the usual pests

**Weather**

**Figure B1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

Like other cooperator sites, xx saw a cool and dry spring. Starting around June conditions were back to average temperatures and the cumulative precipitation trended higher than the historical average. Overall, in 2022 xx IA had ~x more inches of precipitation compared to the historical average (xx inches).

## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# Appendix M. Kevin Prevo, Bloomfield IA

Wanted to help others.

## Weather

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## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

Kevin 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

## Weather

**Figure B1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

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## Results

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# Appendix O. Kevin Veenstra, Grinnell IA

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

## Weather

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Like other cooperator sites, xx saw a cool and dry spring. Starting around June conditions were back to average temperatures and the cumulative precipitation trended higher than the historical average. Overall, in 2022 xx IA had ~x more inches of precipitation compared to the historical average (xx inches).

## Results

**Figure B2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (left) significantly reduced corn yields by 3 bu/ac, (middle) resulted in a financial savings in all price scenarios, (right) significantly reduced the amount of N applied per bushel of corn.**

# Appendix P. Marissa Waldo, Cascade IA

We've never done strip trials before, so it will be good for us to learn how to do it so that we can continue to track progress and perform our own on-farm research.

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.

## Weather

**Figure P1. Weather in XX, IA (bolded lines) in 2022 as deviation from historical values compared to other cooperator sites (thin lines).**

Like other cooperator sites, xx saw a cool and dry spring. Starting around June conditions were back to average temperatures and the cumulative precipitation trended higher than the historical average. Overall, in 2022 xx IA had ~x more inches of precipitation compared to the historical average (xx inches).

## Results

**Figure P2. Results from XX replicated trial. Compared to his typical N rate, the reduced N rate (*left*) significantly reduced corn yields by 3 bu/ac, (*middle*) resulted in a financial savings in all price scenarios, (*right*) significantly reduced the amount of N applied per bushel of corn.**

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**Funding Acknowledgement**

This work is supported by the Agriculture and Food Research Initiative, grant number F9000315202081 from the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Agriculture.

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**Appendix**

Figure of Galva temperature and cumulative precipitation deviation calculations