Conservation Innovation Grants

Final Project Report **NRCS 68-3A75-4-177**

Grantee Name: Iowa Soybean Association
Project Title: Outcomes Based Nitrogen Efficiency Project for Corn Production

Project Director: Tracy Blackmer
Contact Information: Phone 515-250-8640
Email:tblackmer@iasoybeans.com
1255 SW Prairie Trail Parkway
Ankeny, Iowa 50023

Project Dates:
Project End Date:

Original project objectives were:

1. Evaluate the nitrogen status on 940 corn fields using guided stalk sampling.
2. Evaluate the response and effect of modified N management practices on 520 corn fields.
3. Determine yield comparison to alternate nitrogen management practices on 420 corn fields.
4. Implement a market incentive payment based upon nitrogen fertilization rates reduction.
5. Assemble and evaluate aggregate data for improving nitrogen efficiency.
6. Conduct communications and outreach program regarding results and transferability of methods.
7. Train NRCS-certified Technical Service Providers to coordinate delivery of specific application levels with individual project participants.

Project activities:

1. *Developed educational materials* – Many popular press articles about the project were published in such publications as: ***Successful Farming, Progressive Farmer, Farm Journal, Wallace's Farmer***, ***Iowa Soybean Review***, ***Farm Bureau Spokesman***, ***High Plains Journal***, ***Farm News***, ***Iowa Farmer Today***, and ***the Des Moines Register***. More in-depth information, including data summaries, was presented at ISA's 2006 On-Farm Network Conference. The 45 page poster summary can be viewed at http://isafarmnet.com/agronstudies/05nconf.html. Parts of this summary have been presented at more than 20 meetings connecting with more than 2,000 growers in direct oral presentations. Additionally, more than 3,000 copies of the poster summaries from the conference have been distributed by request. Materials were developed explaining how to use GPS equipment to collect the stalk samples for guided stalk sampling. Protocols for strip testing and guided stalk sampling were updated and distributed to participants and other interested parties from other states. In addition, video has been collected from grower meetings, presentation and field interviews to develop a series of DVDs to educate growers on N management. This video will be used to train growers and TSP's on the need,

methodology and interpretation of the evaluation methodologies used in this project. Presentations were made at various field days including NCRS county field days, Hertz Farm Management, Independent crop consultants, Purdue Top Farmer Seminar, and Conklin's Ag Days. An update of the project was presented to the State Soil Conservation Committee, along with the written materials that have been developed. During harvest season, weekly interviews with participants discussing their trials, their results and the impact they had on their operations were recorded and broadcast on 10 Iowa ag radio stations.

2. *Developed work plan with watershed programs and service providers* – Work plans to integrate with four Iowa watersheds (Pike Run, Boone River, South Fork, and West Buttrick) were completed. Two additional sub watersheds - one south of the lower West Buttrick Creek and one adjacent to the Boone River – were added to the program. The Tipton Creek watershed was expanded to cover more of the area where the ARS CEAP project is monitoring the water quality, including readings on nitrate concentration. Meetings were held with the Iowa Independent Crop Consultants Association and other TSPs comprised mostly of co-op agronomists and nutrient management specialists from livestock companies. Meetings with John Deere and GeoVantage were held to assign their roles and responsibilities for the project. In addition, a special meeting was held in conjunction with the On-Farm Network Conference for County SWCD Commissioners. Meetings have also been held with state agencies, including a briefing to the state tech committee on this project. Data processing and report generation agreements were made with Southern Illinois University – Edwardsville and AGRS Consulting Inc., a private company. Work with MGT Consulting provided a basis for consultants/TSPs to recruit fields for guided sampling, collect management information and samples for guided stalk nitrate testing.

3. *Sought additional resources* – Agreements with fertilizer companies have been reached to help subsidize and obtain liquid N fertilizer for side-dressing. This is significant because some co-ops will not guarantee the availability of liquid N and those that will guarantee availability won't lock in fertilizer prices which have increased dramatically. In addition, equipment companies are providing equipment for side-dressing, controllers and GPS equipment to help implement trials. While some media has been purchased for this project, a lot of media coverage has been delivered free of charge. A proposal was presented to the State Technical Committee to set aside money for growers to apply for EQIP funds to cover the strip testing or guided stalk testing without having to go through the county office. While the state tech committee recommended $2,000,000 set aside for special projects, final action from the NRCS of such set asides and their specific allocations have not yet been decided. Funding from Altria was obtained to help with the N conference in February of 2006. A different grant from the McKnight Foundation was received to develop a plan to expand this project to the Upper Mississippi Watershed area. The Iowa Department of Agriculture and Land Stewardship will provide another $400,000 of funding for the second year of this project. The Iowa Soybean Association renewed its commitment of more than $400,000 in checkoff funding for on-farm and watershed work for the 2006 season. Funding was obtained for strip testing and guided stalk sampling in the Pike Run watershed from The Nature Conservancy for next year. The Boone River RCD received a grant from the Iowa DNR for strip testing and guided stalk sampling in their watershed for next year.

4. *Trained service providers* – Meetings with the Iowa Independent Crop Consultant Association were held to train TSPs on the details of this programming, how to execute it and how to sign up growers. In addition, meetings with other TSPs occurred at different grower meetings around the state that involved mostly co-op agronomists and livestock consulting companies. Training for the strip testing and guided stalk testing were provided through several vehicles. The primary vehicle was direct training of the TSPs or directors of TSPs. This occurred through structured meetings, written materials and field visits. Written materials included protocols, examples of application/end use, and articles in popular farm press showing its application in a comprehensive strategy. Example of written materials can be viewed at www.isafarmnet.com.

5. *Tracked participation in strip testing and market based incentives* – We collected sign-up information for different levels of the program. There are three types of participation to track:

a) Market based incentives. The payments for growers to apply 100 lbs of N or less (state average is about 150 lb N/a) was extremely popular. It took less than one week to sign up the 100 participants we were looking for. In the several years I have worked at ISA, no other topic has generated so many calls to our office. Because many of our previous cooperators have reduced their rates to 100 lbs N/a, we did a public announcement through the radio, ***Farm Bureau Spokesman***, and ***Iowa Farmer Today*** newspapers to reach a "new" pool of growers. We underestimated the response of the program. While many new growers signed up, many other growers called in to argue you couldn't grow corn profitably on 100 lb N/a. At the end we capped enrollment to 103 growers and at present date, 96 growers from 51 of Iowa's 99 counties have met the criteria to get paid.

b) Replicated strip testing. More than 200 sites were verified, however, this was less than our target. Many of the priority sites – comparing fall vs. spring application and manure type trials were implemented. Liquid fertilizer availability and price volatility negatively affected the implementation of the trials.

c) Guided stalk sampling. More than 1,300 fields were signed up (target was 1000) from all 99 of Iowa's counties. A combination of complications from collecting aerial remote sensing and an early harvest resulting from an above average August/September temperatures occurred this year. The collection of remote sensing was complicated by intermittent GPS signals around 9/11/2005 and the rapid senescence of the corn crop. As a result of the delay of obtaining usable imagery, some fields were harvested before the TSPs could sample them.

6. *Collection of management information*. All data was collected from all the trials and verified for incentive based payments. More than 1,000 fields were successfully completed for the various aspects of the project. Payments to growers with the market-based incentives were made shortly after submission of their yield data.

7. *Coordinate collection of imagery and stalk sampling collection*. More than 1,300 fields were signed up for the guided stalk sampling program. Specific field locations were identified and a spatial boundary

identified for each field was created in a shapefile. These shapefiles were used to guide image acquisition starting in mid-August.

All aerial imagery was collected by GeoVantage. The data was then checked and processed by ISA and combined with the soil survey map units to pick appropriate sampling points for all fields except those where there were replicated strip tests. The replicated strip testing fields were sampled by the sampler picking the points in adjacent strips and marking the sampling locations with three pairs in each trial. This was due to the lack of accurate strip location data that could be used to guide sampling. Most fields with N management strips in them were marked with flags in the headlands so farmers could record strip location at harvest with their GPS and yield monitor.

To ensure the quality of stalk samples collected, special stalk sampling equipment was developed and manufactured by a group of FFA students from the Jefferson-Scranton High School. These samplers are two cutters welded eight inches apart with a six-inch guide to ensure a correct sampling location on the stalk. One of the students involved began own business manufacturing these stalk sample cutters and agronomists and scientists from as far away as Rutgers University have been ordering them.

Except for the strip trials, the points for stalk sampling were predetermined by ISA and loaded on handheld GPS units that:

a) Guided samplers to the sampling sites

b) Gave an identification number for the sampler

c) Recorded actual sampling location to ensure sample was collected from appropriate location.

Sample bags, stalk cutters, GPS units, maps, and protocols were distributed to the various samplers. Fifty sets of equipment were assembled and distributed. Personnel from ISA transferred equipment between different samplers and coordinated sample delivery to the testing lab. A final tally has not been made yet, but it is estimated that more than 100 people were trained and contracted with for sampling. All samples were frozen if not delivered to the testing lab the next day. All samples were inventoried before submission to the laboratory.

Collaboration with the Iowa State University soil testing lab was set up to expedite sample preparation and lab analysis. Cloth sampling bags were purchased and distributed to samplers so stalk samples could be dried quicker. Extra staff was hired by the ISU lab to process and analyze samples in a more timely fashion.

In excess of 4,771 stalk samples had been collected at the time of this report. Results of the stalk nitrate sample testing are posted by county on the web at www.isafarmnet.com. A central database with management information and stalk nitrate results was finalized and used to organize and store all data electronically.

8. *Collection of replicated strip trial data*. Replicated strip trial data were analyzed and individual grower reports distributed to the participants. More than 200 trials were successfully completed. Guided stalk sampling reports were generated for each grower and distributed to the growers and group leaders. All payments to growers were held until all their data, including yield data, was submitted. Payments to growers with the market-based incentives were made after verifying that the management practice was completed, using receipts for fertilizer from the selling dealers.

Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

1. Evaluate the nitrogen status on 940 corn fields using guided stalk sampling.

More than 1,000 fields were successfully executed.

2. Evaluate the response and effect of modified N management practices on 520 corn fields. Three main techniques were used to achieve this objective:
    a. Using replicated strip trials so growers could compared two management practices in alternating strips in the same field.
    b. Incentivized payments to growers for reducing N rates for an entire field and monitoring N status in the field with the guided stalk testing.
    c. Individual growers compared multiple fields, each with a different management practice.

    More than 500 comparisons were made, but the most effective method was the use of the replicated strip trials.

3. Determine yield comparison to alternate nitrogen management practices on 420 corn fields. There were two main methods of making yield comparisons:
    a. Replicated strip trials
    b. Comparisons of yield from field to field with different management practices as well as the guided stalk testing.

    Replicated strip trials were the most effective means of evaluating N management practices. Grain yield varied greatly between fields, caused by a wide variety of factors that were not necessarily related to nitrogen status. Also, the difference in yield varied so much, that a field level yield assessment was not useful. For most growers, the yield difference of about 4 bu/a had the same cash value of 50 lbs N. Aerial imagery and stalk nitrate testing were much more indicative of N stress. Unless yield comparisons of different management practices were made in the same field with all other factors (like hybrid, planting date, crop rotation, etc,) the same, they were not useful in assessing the N management of a given field.

4. Implement a market incentive payment based upon nitrogen fertilization rate reduction. The payments for growers to apply 100 lbs of N or less on an entire field (state average is about 150 lb N/a) was extremely popular. It took less than one week to sign up the 100 participants we

were looking for. We capped enrollment at 103 growers. At the end of the season, 96 growers from 51 of Iowa's 99 counties met the criteria to get paid. However, this practice was more expensive to execute than the monitoring portions of the project. Without the in-field comparisons or the field-to-field comparisons, growers in general were not convinced reducing N rates below 100 lbs. per acre was worth the money unless they were already doing this.

5. Assemble and evaluate aggregate data for improving nitrogen efficiency.

   The data was aggregated and evaluated in a number of different ways. See attachments in this report for several examples.

6. Conduct communications and outreach program regarding results and transferability of methods.

   There has been a very strong outreach component that has had a big impact. Many of the activities are listed earlier in this report and some examples are attached in this report.

7. Train NRCS-certified Technical Service Providers to coordinate delivery of specific application levels with individual project participants.

   This has been probably the biggest impact of all the funding for this project. Many of the crop consultants and TSPs were not well familiar with the aerial imagery or stalk nitrate tests and standardized training and hands-on traning to interpret the results with them and their clients have impacts beyond the growers directly involved in this program.

We successfully implemented programming that is related to the seven project objectives. There were two interesting factors that influenced the implementation of management practices during this year:

1. The rising price of N. Sharp increases in energy costs impacted fertilizer price and availability. It could be anticipated that higher N prices would automatically lower N application rates. Growers would typically contemplate applying liquid fertilizer as side-dress even though it costs more than other forms of N because they believe they would require less due to lower N losses.
2. As a result, many co-ops won't guarantee liquid N availability or predict a price if it becomes available. This has impacted a number of cooperators who do not want to risk being caught without fertilizer. Results from the 2004 season showed large areas of reduced yields due to N loss resulting from the above average spring rainfall in Iowa. Liquid N application showed higher losses than anhydrous ammonia and that is also affecting grower participation.

Theevaluation methodologies implemented in this project have become offered as eligible for EQIP in a few Iowa counties. We are providing support and helping to identify contractors for components needed in these counties. Currently, ISA is providing the link that permits the combination of data across individual observations. One component that will need to be developed for full statewide implementation is a central coordination so the benefits from the aggregate database can occur. Organizing a group effort through CSP or EQIP at a county office was challenging. The outside funding made this project happen, because the county offices had difficulty in devising a way to pay for a coordinated project at the county level.

Growers are willing to evaluate their management. The ability of an infrastructure to get participation in a dense area such as a watershed has been proven, with more than 50% of the growers participating. Likewise, broad-based participation is also obtainable as shown by participation in all 99 counties in Iowa.

The technology is still not perfected as shown with the difficulties of obtaining aerial imagery in a timely fashion. Training not only on how to sample, but on how to use GPS equipment was a significant undertaking. Both of these issues were dealt with and likely could not have been feasible two years ago on the scale implemented this year.

There is considerable need to further train both TSPs and growers on interpreting results and using them to adjust their management. Further consideration is needed regarding handling discrepancies between current standards and evaluating data that shows the standard is not optimal for a given scenario or circumstance. There is a growing concern about the value of conducting an evaluation if it suggests implementing a practice not covered by the 590 standard or other nutrient guidelines. There is a clear value in understanding how evaluations can be used to support the 590 standard and other nutrient guidelines.

Stalk testing without accompanying yield data was less convincing to growers. Grower confidence in the guided stalk sampling fields was higher in groups where there was an example that contained both yield response and stalk nitrate data. The yield data needed to be from differences documented within the same field, not between fields, to make better N management interpretations.

It was less expensive and more effective to pay for replicated strip testing that resulted in proven yield differences than to pay for rate reductions on entire fields. Fewer than ten acres, or alternating strips of an alternative practice, provided a strong comparison for growers to evaluate. When yields are recorded with a yield monitor, the results were more convincing than those from the guided stalk sampling fields.

It was generally recognized that multiple years of data are needed to instigate a dramatic change in grower behavior. Participating growers wonder if the results would be the same the next and in subsequent years.

Besides evaluations, growers consider the cost and availability of the various forms of nitrogen fertilizer to be more of a factor in the amount used than the specifics of efficient management. High energy prices and related volatility in nitrogen fertilizer increase growers’ fear that delaying applications until spring or sidedressing time will be more expensive than fall applications, even if they must use a higher rate in the fall.

Funding received and Expended

Overall, $1,801,846.12 was expended with half being federal funds and half being non-federal funds.

The following are lists of payments made to growers.

List 1. Is payments for market incentives for this project.

Last	First	Company	SSN / Tax ID	Payment Amt
Abels	Fred	K&A Acres Inc.	16-1674448	$922
Bailey	Dennis		479-56-0342	$500
Bogaards	Dennis	Bogaards Farms Inc.	39-1871182	$1,175
Borchardt	Vaughn		479-76-5243	$1,448
Brandt	Jeff	Coyote Farms Ltd.	42-1382014	$2,000
Brauer	Gerald		484-42-9202	$1,200
Bridges	Thad	Quarry Farm	333-58-9376	$975
Brunk	Steven	Lean Pork Lane Ltd.	485-72-6167	$1,750
Carroll	Doug		483-92-2559	$2,000
Christensen	Dan	Dan & Sarah Christensen Inc.	42-1515572	$1,950
Cobie	Rick		479-76-0145	$600
Degner Sr.	David		485-54-6192	$1,750
DeJong	Paul	DeJong Bros	563-90-4104	$1,400
Devig	Eric		484-80-4343	$2,000
Dunn	Matt		483-62-2167	$1,905
Duschen	Harvey		481-58-3935	$575
Flammang	Kirk		484-70-0749	$1,950
Fogle	Dennis		482-86-0269	$998
Fouch	Steve		482-74-1532	$1,698
Friest	Brent		485-82-8841	$1,843
Gevock	Jim	Gevock Farms	480-68-5977	$600
Griesse	Dave		485-88-7186	$1,250
Handeland	Wade		482-94-8309	$1,200
Hardy	Denny		484-56-8726	$2,000
Heidelberger	Gary		503-48-7396	$2,000
Hermsen	Allan		483-72-5729	$1,795
Higgins	Daryl		481-88-5546	$2,000
Honkomp	Ron		479-68-9948	$2,000
Hoversten	Rodney		481-72-4548	$710
Huser	Tim		478-62-2959	$978
Jensen	John (& Bud)		Bud 478-22-0376, John 485-72-0079	$645
Johnson	Kurt		484-80-3444	$2,000
Kanne	Neil		479-62-0063	$1,396
Kersey	Darrell		505-38-3749	$846
Kimberley	Harry & Kevin	K & B Grain Farms Ltd.	42-1418858	$1,248
Kimberley	Rick	Kimberley Farms Inc.	42-1108207	$1,400
Kraus	Dan	Kraus Farm	481-82-6102	$1,110

Kromminga	Steve		485-64-7839	$1,600
Kruger	Dennis	DK Farms Inc.	42-1405150	$1,580
Linder	Howard		483-38-6320	$1,700
Luthro	Nathan		478-36-4046	$1,977
Lynch	Gerald	Lynch Livestock/Joe Portz	484-60-9583	$1,360
Mateer	William	Mateer Inc.	485-54-3531	$1,000
Mattox	Jim		498-66-2497	$1,935
Mens	Paul		485-72-1209	$1,200
Morain	D.J.		483-48-5824	$1,155
Mordhorst	Jeff		479-82-5903	$830
Movall	Mark		478-98-7684	$1,938
Nelson	Craig		485-04-9798	$870
Niewoehner	Brad		478-90-1835	$1,953
Niewoehner	Dean		483-54-9913	$1,808
Nolte	Doug		478-86-8210	$1,600
Petersen	Allan		480-58-0058	$1,200
Pithan	Leonard	Pithan Farms	480-34-9494	$1,050
Plagge	Curt	Plagge Farms, Inc.	42-1105405	$1,200
Renger	Tim		483-72-3258	$1,950
River	Bruce		478-66-4254	$1,260
Roeder	L.R.		479-46-7609	$1,325
Rotterman	Bill		469-64-4232	$1,600
Rottinghaus	Mike	Twin Creek Farm Ltd.	42-1123204	$1,860
Schindel	Brad		483-64-6558	$1,833
Schindel	Gary	Schindel Agri-Sales	42-1062054	$1,113
Schulz	Ron		485-68-9149	$2,000
Smith	Tony		479-13-1760	$945
Soukup	Doug		478-84-8543	$2,000
Spicer	Keith	Spicer Inc.	481-34-3282	$1,200
Spies	Paul		485-74-8637	$1,383
Spies	Mark	Diamond S. Farms	482-86-5151	$630
Staudt	Dennis		481-58-9501	$1,875
Stracke	Phil	Thomson-Stracke PTR	42-1345017	$1,690
Tjelmeland	Mark	Tj Family Farm	42-1177046	$1,325
Ulch	Ed		481-50-3679	$2,000
Ulch	Brian		485-90-3193	$1,875
Valvick	Arlyn	Ark Farming	481-86-7194	$2,000
Vander Wilt	Arvin		478-48-7397	$450
Visser	Marlyn		481-60-8657	$1,200
Wauters	Ken		481-58-2986	$1,825
Weber	Robert		508-78-6715	$2,000

Wendt	Eldean		478-50-3409	$885
Wernimont	Al	Wernimont Farms	482-62-6802	$2,000
Wheeler	Randy		485-74-6443	$825
Wilcox	John	Wilcox Farms Inc.	20-0837899	$1,600
Willer	Mike	Mike Willer Farms	481-80-2401	$1,600
Zelle	Ronald	Mary Beth Zelle	485-86-3470	$375

List 2 is for payments for Replicated Strip Trials

GROWER LAST	GROWER FIRST	Company/FarmName	TaxID/SSN	Total Payment
Alber	Greg		481-92-3347	$495.00
Alliger	Larry		480-84-5865	$990.00
Augustine	Dan	Augustine & Sons Inc	42-1199315	$280.00
Ausburger	Dave	Ausberger Farms, Inc.	483-81-1692	$1,167.50
Blome	Mike		478-60-7518	$400.00
Bogaards	Dennis	Bogaards Farms Inc.	39-1871182	$227.50
Bravard	Mike		478-72-6882	$997.50
Burnell	Rich	Burnell Trucking Ltd	480-60-4512	$735.00
Butt	Kevin	Ellsworth Community College	42-6076485	$200.00
Chesnut	Scott	Circle C Farm Corp	42-1331337	$867.50
Claude	Mark	Claude Farms Inc.	480-80-0148	$497.50
Coburn	Bruce	Coburn Bros Ltd	42-1119587	$282.50
Coburn	Lee	Coburn Bros Ltd	42-1119587	$367.50
Coleman	Dean		484-78-6048	$1,075.00
Crawford	Mark	KLM Farms	42-1364142	$400.00

Crouse	Dale	Crouse Farm Inc	39-1892468	$525.00
Daufeldt	Marlin		478-58-7257	$307.50
Davison	Wendell	DGL Inc.	42-1486325 / 42-1282351 Clausen Farm	$2,630.00
Deo	Bob		42-1131950	$555.00
Doerder	Daryl	Doerder Farms	483-77-5514	$832.50
Doran	Jim		483-86-9836	$417.50
Elliott	Craig	DBA Elliot Farms	42-1378192	$520.00
Fields	Pat	Fields Farms Inc	478-78-1584	$412.50
Fredericks	Wayne		478-68-1310	$870.00
Frederickson	Jack		485-58-7319	$427.50
Friest	Denny	Friest Farms	41-1127791	$4,140.00
Fulton	Roy		507-48-9039	$437.50
Gaesser	Ray	Gaesser Farms	306-52-9398	$632.50
Gerholdt	Dennis		484-92-7771	$916.50
Gisleson	Jon		485-74-1404	$535.00
Gordon	Marv	Gordon Farms Inc	42-1179040	$200.00
Gourley	Farms	Gourley Bros LC	42-1427917	$1,450.00
Groves	George	Groves Bros Inc	42-1362589	$207.50
Hammitt	Gary		485-76-6300	$592.50

Henry	Steve	Henry Corp	42-1434448	$797.50
Hodnefield	Glen		485-74-7923	$552.50
Humpal	Ken	AMK Farm	42-1345408	$1,345.00
JA	Pork	J & A Pork	42-1274833	$810.00
Juon	Jim		484-48-6242	$400.00
Kantak	Kreg		481-86-4732	$200.00
Karkosh	Alan	K & O Farms Inc	484-56-3577	$297.50
Keane	John		479-56-4082	$200.00
Kielkopf	John		485-86-1280	$1,152.50
Krantz	Dverg		478-54-9943	$346.75
Krause	Karlton		483-88-4998	$682.50
Krause	Kent		483-88-5009	$400.00
Krause	Kurtis		483-88-4894	$832.50
Lage	Mark		484-80-8592	$436.50
Leibold	Nick		484-80-7861	$1,587.50
Lewis	George		Deceased, send check to his wife	$200.00
Lindsay	Dennis	Lindsay Farms	480-60-6482	$400.00
Lindsay	Scott		479-06-9452	$557.50
Maloy	Shannon		481-94-3934	$305.00
Moore	Frank		202-69-3788	$752.50
Wearda	Travis	Nedved Ag	42-1513191	$325.00

Norby	Randall		478-68-1091	$521.00
Oswald	Tom		478-58-9097	$352.50
Palmersheim	Bill		480-64-8080	$585.00
Poe	Greg(ILCC)	Iowa Lakes Community College	42-0929936	$1,412.00
Porterfield	Jim		87-6258580	$418.12
Rabe	Joe		482-80-7129	$492.50
Richardson	Jim		484-54-8224	$510.00
Schmidt	David		479-60-0956	$210.00
Seidl	Steve		483-62-5396	$485.00
Seil	Dave	D & B Farms	39-1876112	$420.00
Shelton	Britt	Britt Shelton, Shelton / Hay Ag Inc	1/2 to each operation 74-3084283	$717.50
Sindergard	Curt		478-76-0782	$817.50
Smith	Travis		485-02-4571	$398.13
Stillman	Jim	Generations Farm Inc	480-60-4662	$217.50
Stromer	Dean		480-70-8304	$557.50
Sutton	Bill		480-56-1268	$1,045.00
Titman	Marte		485-86-8436	$960.00
Towers	Brothers	Towers Brothers	482-86-9846	$557.50
Ventling	Wayne		20-407-3620	$285.00
Walker	Doug		478-56-4553	$522.50

Wiley	Steve	Wiley Farms	481-74-0303?	$505.00
Young	Dave		485-60-3234	$912.50

Results

Inserted in this section are 30 pages that are a small subset of the summary of results and tech transfer information used from just one of the publications generated relating this project. Hardcopy reports were sent to the Iowa NRCS State office and National Technical representative as part of periodic reporting. Over 1,500 pages of hard copy reports of the individual trials were delivered to the NRCs representatives at the state and Federal level as well as being placed on the website for a period of at least two years. Many of the actual results and summaries can be viewed on the website www.isafarment.com. On this website there are many of the tools used, presentations, individual evaluation results.

Learning to manage nitrogen economically and environmentally

A search for sound science on which to base nitrogen management decisions has led to a statewide network of farmers working together to improve profits and the environment.

Corn growers know – and have for years – that nitrogen is a crucial element in corn production. When used properly, it helps optimize yield and consistency in nutrient content of the grain.

Properly nourished plants are healthier, more prolific, more competitive with weeds and insects, and survive drought and hot weather better. So the traditional thought was apply as much nitrogen as was necessary to maximize yields.

Not everyone looked at it this way, though, because economics suggested that nitrogen application rates should be adjusted as nitrogen and corn prices rise and fall.

Some 25 years ago, when Dr. Alfred Blackmer and other research scientists at Iowa State University and a few other universities began looking seriously for the science behind nitrogen use recommendations of 1 to 1.2 lb. of nitrogen per bushel of yield, they found the supporting data to be questionable.

Then another factor was forced into the picture: the environment. An apparently worsening hypoxia condition at the mouth of the Mississippi River in the Gulf of Mexico, likely caused by increased amounts of nitrogen and phosphorus dissolved in water, implied that farmers might be the cause – or at least part of the cause of a potentially devastating environmental problem.

The lack of sound science for both yield goal recommendations and linking fertilizer use to the situation in the Gulf prompted the farmer directors of the Iowa Soybean Association to begin its own search for truth.

In the late 1980s, with the backing of producer funding, Dr. Blackmer began working directly with growers to determine what nitrogen use rates produced corn most economically. The Iowa Soybean Association joined in, helping fund a study of water and farming practices in the Raccoon River watershed. This eventually led to formation of a group within the association to design and facilitate watershed planning and on-farm crop nutrient studies in order to continue the search for the connection between farm fertilizer use and water quality.

Searches, even those for the truth, cost money. Initial financial support from the soybean checkoff has been leveraged with additional funding from the Iowa Department of Agriculture and Land Stewardship's Integrated Farm and Livestock Management program, some of which has been earmarked specifically for our use by the Iowa Legislature. Additional support has come from the USDA's Natural Resources Conservation Service. All of this has allowed the association's different On-Farm Network™ projects to expand from just a few farms in 2000 to the point that they reached every county in the state this year.

What early On-Farm Network cooperators like Ron Heck, Dennis Friest, Jim Andrew and scores of others have learned by comparing normal and reduced nitrogen application rates in replicated strip trials has shown them the way to lower application rates.

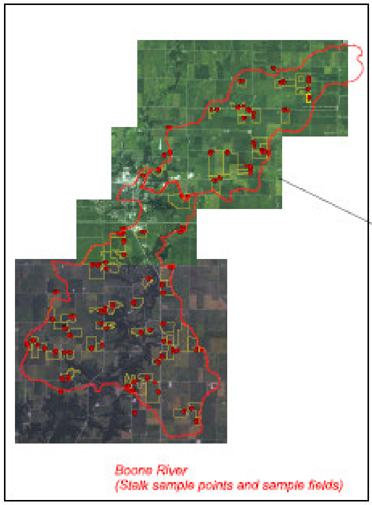
Not every farmer can cut nitrogen rates, but many have already done it on their own. When we announced a project last spring to provide a cash incentive for 100 growers to cut nitrogen use to 100 lbs. or less on a field up to 80 acres in size this past year (paid for with an NRCS Conservation Innovation Grant), Christine Borton, our programs administrator, was immediately inundated with calls. Most of the growers in the program were routinely using lower nitrogen rates, so cutting back to 100 lbs. or less was not much of a stretch for them.

Cutting nitrogen application rates may require a change in timing, application method, or fertilizer form. This proceedings contains research results and observations from replicated strip trials conducted by farmers participating in the Iowa Soybean Association On-Farm Network™ that should help all Iowa farmers to minimize nitrogen use while maximizing return per acre.

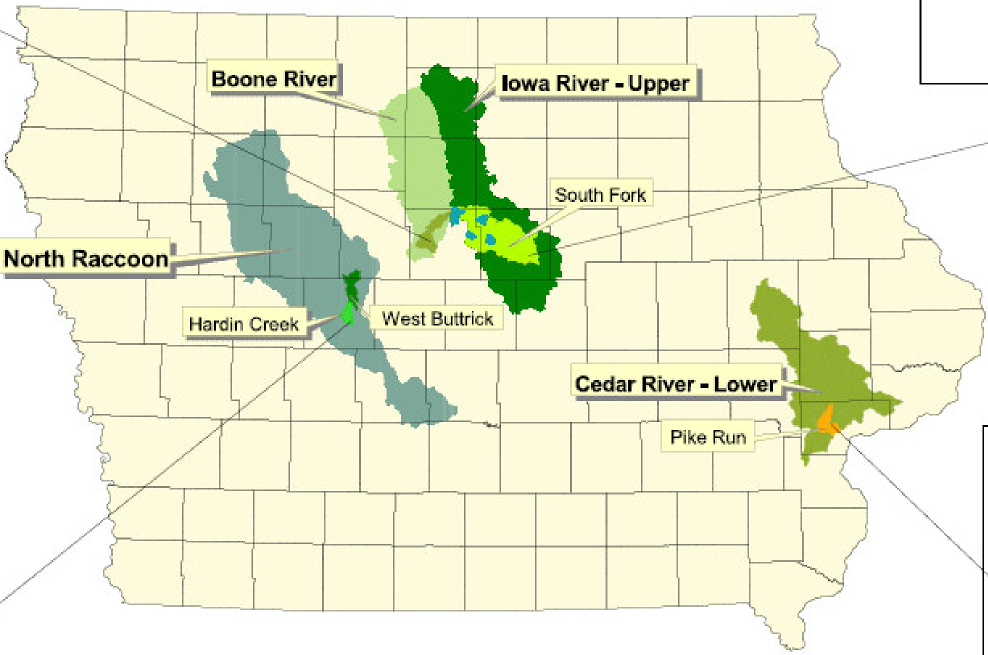
Take a look at what other farmers have learned. Then look for ways to apply or adapt their findings to your own farm. For help in setting up your own trials, or to become a cooperator in the On-Farm Network, contact the Iowa Soybean Association and we'll gladly help you through the process.

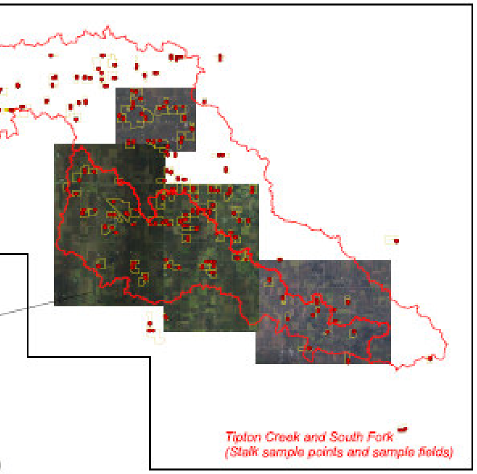
Iowa Soybean Association

Watershed Programming

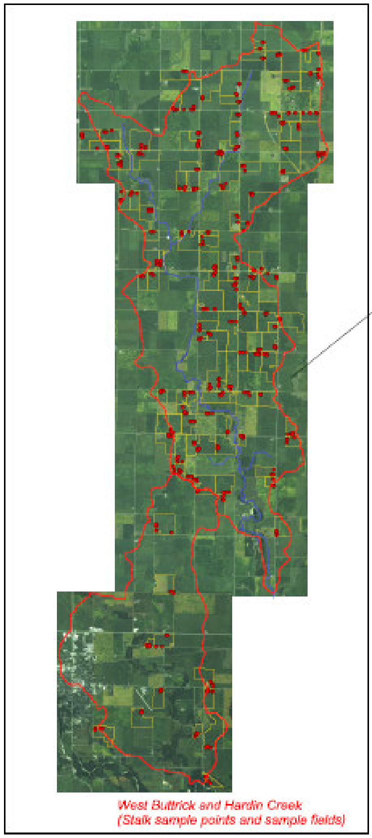


Boone River
(Stalk sample points and sample fields)

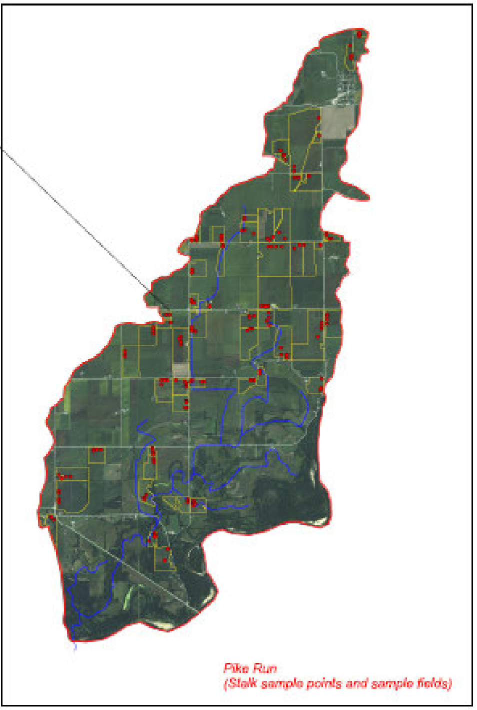




Tipton Creek and South Fork
(Stalk sample points and sample fields)



West Buttrick and Hardin Creek
(Stalk sample points and sample fields)



Pike Run
(Stalk sample points and sample fields)

ISA Watershed Programming

ISA watershed programming provides leadership and applied environmental research supporting organized watersheds. ISA coordinates its programming as part of a comprehensive watershed management effort. Area wide and individual technical and program planning assistance is supported, in addition to management evaluation, applied research, and communication efforts.

Evaluating Management Practices and Environmental Outcomes at the Watershed Level

ISA watershed programming applies a multi-phased management practice and environmental outcome evaluation. Each phase is iterative and features combinations and use of information technology tools, methods, and evaluation design. Production data is collected and analysis is performed to evaluate response to management and correlation with variables such as soil types, tillage and fertilizer application rates, timing and sources. The effort becomes a participatory learning experience for growers bolstered by science and data.

IOWA SOYBEAN
ASSOCIATION
Expanding Opportunities. Delivering Results.

Buttrick Creek watershed project - N evaluation

Project Description

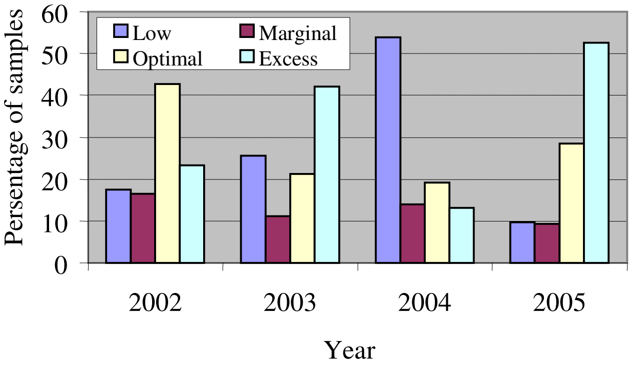
The West Buttrick Creek Watershed Demonstration Project has completed four years of nitrogen management evaluation on the majority of corn fields in the 27,000 acre watershed.

The watershed is representative of the much larger North Raccoon River watershed with extensive field tiling, high nitrate concentrations in the water, intensive row crop production, and some livestock.

The focus on the first three years of this project has been on starting the evaluation process. The evaluation process to date encompasses:

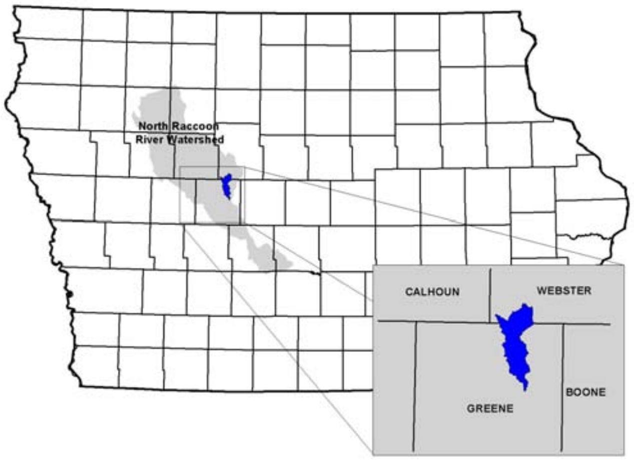
1. Use of guided stalk sampling
2. Use of replicated strip tests to evaluate response to management

Evaluation Results for Years 2002 - 2005



- More than 50% of the samples collected in 2004 showed N stress significant enough to reduce grain yield.
- Only 10% of the samples in 2005 were low, while more than 50% were in the excess category.

Project Location



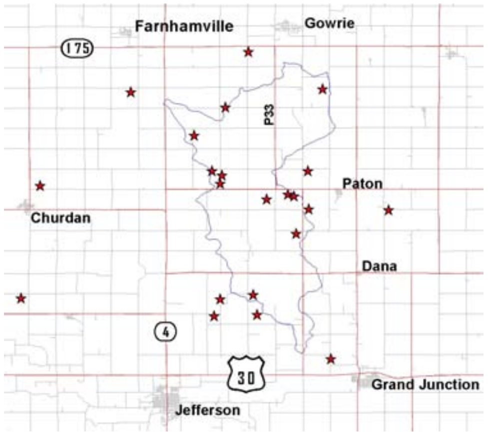
Example of Management Comparisons

Concern over the loss of fall-applied anhydrous from corn fields has caused many people to ask what the alternatives may be and how effective they are. Prior years' testing showed broadcast liquid N to be a concern in the watershed. Few people were applying spring anhydrous so comparisons were difficult. Below are the stalk nitrate analysis results that show similar results for fall anhydrous and spring applied N. These results are consistent with yield results from the fall vs. spring strip tests.

Sample	Fertilizer	N Rate	Stalk Nitrate	Grain Yield
numbers	timing	(lb N/A)	(ppm)	bu/A
164	Fall	162	2799	202
167	Spring	153	2774	185

The Next Level

Many locations of replicated strip trials were set up for a second season. The predominant factor being tested was the fall vs. spring application of N. Below is a map showing the coverage of this year's trials.



Partners

- Iowa Soybean Association
- Natural Resources Conservation Service
- Greene County Soil and Water Conservation District
- Texas Institute For Applied Environmental Research
- USDA National Soil Tilth Lab
- Iowa State University
- Agriculture's Clean Water Alliance
- Iowa Dept. of Agriculture and Land Stewardship (Integrated Farm and Livestock Management Program)
- Des Moines Water Works

South Fork watershed project - N evaluation

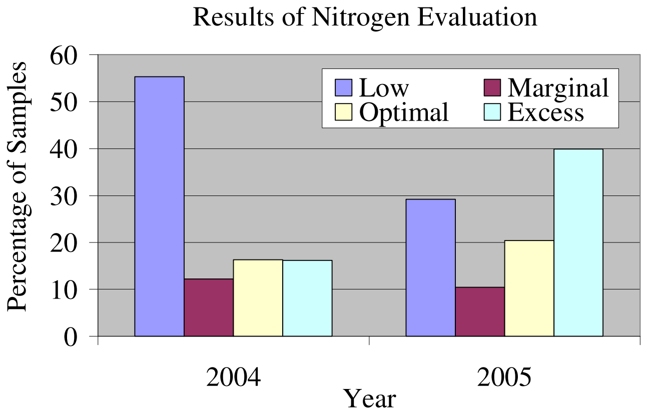
Project Description

The second year of nitrogen management evaluation was done to support farmer participation in the South Fork Watershed Project. Farmers enrolled more than 100 corn fields and collected over 400 guided stalk samples from select areas of the 200,000 acre watershed.

The watershed is representative of the much larger Iowa River - Upper Watershed where there are high nitrate concentrations found in the water, and intensive row crop and livestock (mostly hog) production. Because of the intensive livestock production, there is also a significantly higher percentage of second year corn.

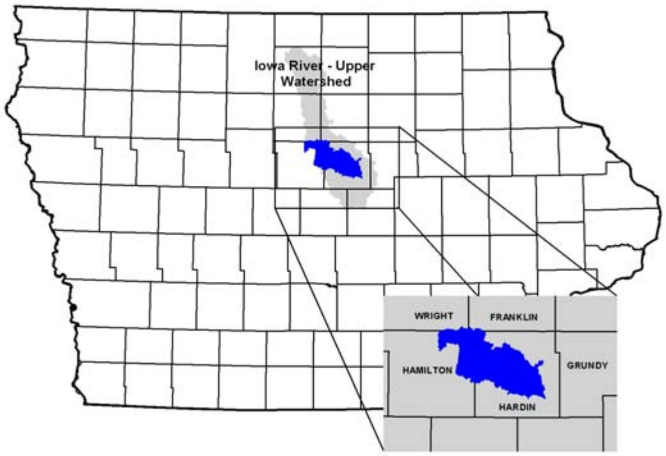
Water quality monitoring has been taking place as part of the CEAP program being overseen by USDA-ARS National Soil Tilth Laboratory.

Evaluation results for years 2004-2005



Lower rainfall amounts in 2005 resulted in fewer low testing samples and increased the number of samples that tested in the excess range.

Project Location



Example of Management Comparisons

The high rainfall and subsequently high N loss resulted in low stalk nitrate levels in 2004. In 2005, lower rainfall amounts made it possible to make more management comparisons. Below is a table with an example of the results from the stalk testing on the corn following corn fields.

Sample Numbers	Fertilizer Source	N rate (lb N/A)	Stalk Nitrate (ppm)	Grain Yield (bu/A)
120	NH3	183	2167	196
32	UAN	153	901	192
61	Manure	185	1691	198

Of the three fertilizer sources, all three had similar yields. The amount of N varied as did the stalk nitrates. The fields receiving manure used more total N and had lower stalk nitrates than fields receiving anhydrous ammonia.

Manure Management

In addition to executing the broad scale stalk testing program, sidedressing of additional N on manured soils was evaluated. Replicated strip trials (with yield measurements) were implemented in the 2005 season. Because of all the livestock, there is special interest in the availability of N from various manure sources.

Next Steps

In addition to executing the strip testing and stalk testing program, both the late spring soil nitrate test and the sidedressing of additional N on manured soils will be further evaluated. There will also be more testing of tools to better evaluate and predict N requirements within a field. How to credit N availability from manure is also a likely focus due to the large livestock presence.

Partners

Iowa Soybean Association
Hardin County & Hamilton County Soil and Water Conservation Districts
Natural Resources Conservation Service
Southfork Watershed Alliance
USDA National Soil Tilth Lab
Iowa Dept. of Agriculture and Land Stewardship (Integrated Farm and Livestock Management Program)
Iowa State University

Boone River watershed project - N evaluation

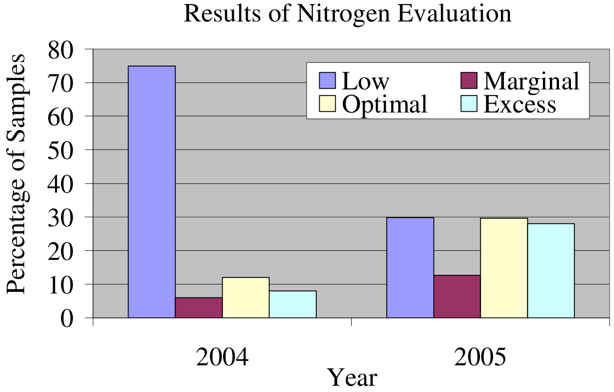
Project Description

The second year of nitrogen management evaluation was done to support farmer participation and evaluate one of the priority resource concerns within the Boone River Watershed Project. A majority of the corn fields in the 20,000 acre sub-watershed were enrolled in the program.

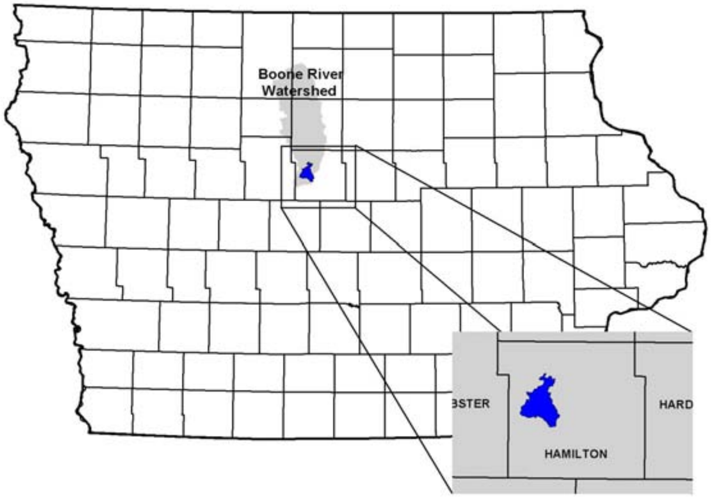
This sub-watershed is representative of the much larger Boone River Watershed where there are high nitrate concentrations found in the water, along with intensive row crop and livestock (hog) production.

The focus of the second year of this project has been on continuing the evaluation process with the use of guided stalk sampling, and expansion of strip testing.

Evaluation Results for Years 2004-2005



Project Location



Example of Management Comparisons

Below is an example breakout of the stalk testing results from 2005. All of the data is from corn following soybean fields. The table below gives an indication that more strip testing, focused on the timing of fertilizer application, may be in order, based on what the stalk tests have shown.

Partners

Iowa Soybean Association
The Nature Conservancy
Hamilton County Soil and Water Conservation District
Prairie Rivers of Iowa Resource Conservation and Development
Natural Resources Conservation Service
Iowa Dept. of Agriculture and Land Stewardship (Integrated Farm and Livestock Management Program)
Iowa State University

Other Comments

The 2004 crop season had way above normal rainfall and the amount of N deficiency detected in the imagery and stalk tests confirmed this. The 2005 season had a wider range of conditions making comparisons easier with the stalk tests. In addition to the differences in timing, differences in fertilizer sources were also detected. To expand beyond the stalk testing, more than 30 replicated strip trials were implemented in 2005.

				Stalk Nitrate Categories				
Sample	Application	N rate	Stalk Nitrate	Percentage of Samples by Category				Grain Yield
Numbers	Timing	(lb N/A)	(ppm)	Low	Marginal	Optimal	Excess	(bu/A)
76	Fall	169	1178	41	16	22	21	192
190	Spring	156	1554	26	13	35	26	188
14	Sidedress	89	2807	14	0	21	64	225

Pike Run watershed project - N evaluation

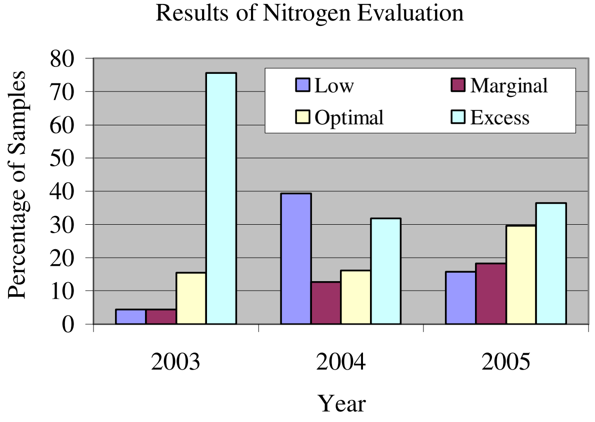
Project Description

The third year of management evaluation was done to support farmer participation in the Pike Run Watershed project. A majority of corn fields in the 12,800 acre watershed were enrolled in the program.

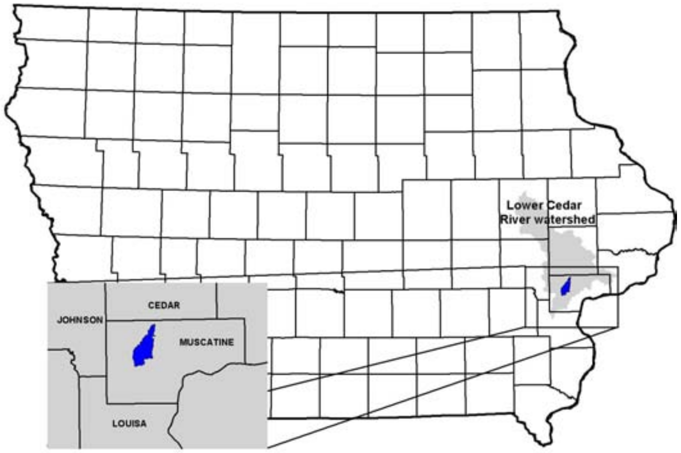
This sub-watershed is part of the Lower Cedar River Watershed. There is considerable corn and soybean production, but there are also many grass and wetland areas. The area under evaluation has many lighter textured soils, little tiling and low nitrate concentrations in the groundwater.

The focus of the three years of this project has been on starting the evaluation process. To date, this evaluation process includes the use of guided stalk sampling and replicated strip tests to evaluate yield response to management.

Evaluation Results for Years 2003-2005



Project Location



Example of Management Comparisons

Below is an example of a summary of the stalk nitrate samples. The results are a subset of the 2005 season for the corn following soybean fields that applied liquid N. This was the predominant practice in the watershed. There was considerably higher stalk nitrate concentrations with the sidedress treatments. This is likely due to the light soils that can lose even spring applied N.

Samples Number	Fertilizer Timing	N rate (lb N/a)	Stalk Nitrate (ppm)	Grain Yield (bu/a)
63	Sidedress	135	2019	97
30	Spring	120	1034	102

Discussion

It should be noted that extreme drought in the area significantly impacted plant growth in 2005, affecting both stalk nitrate content and grain yields.

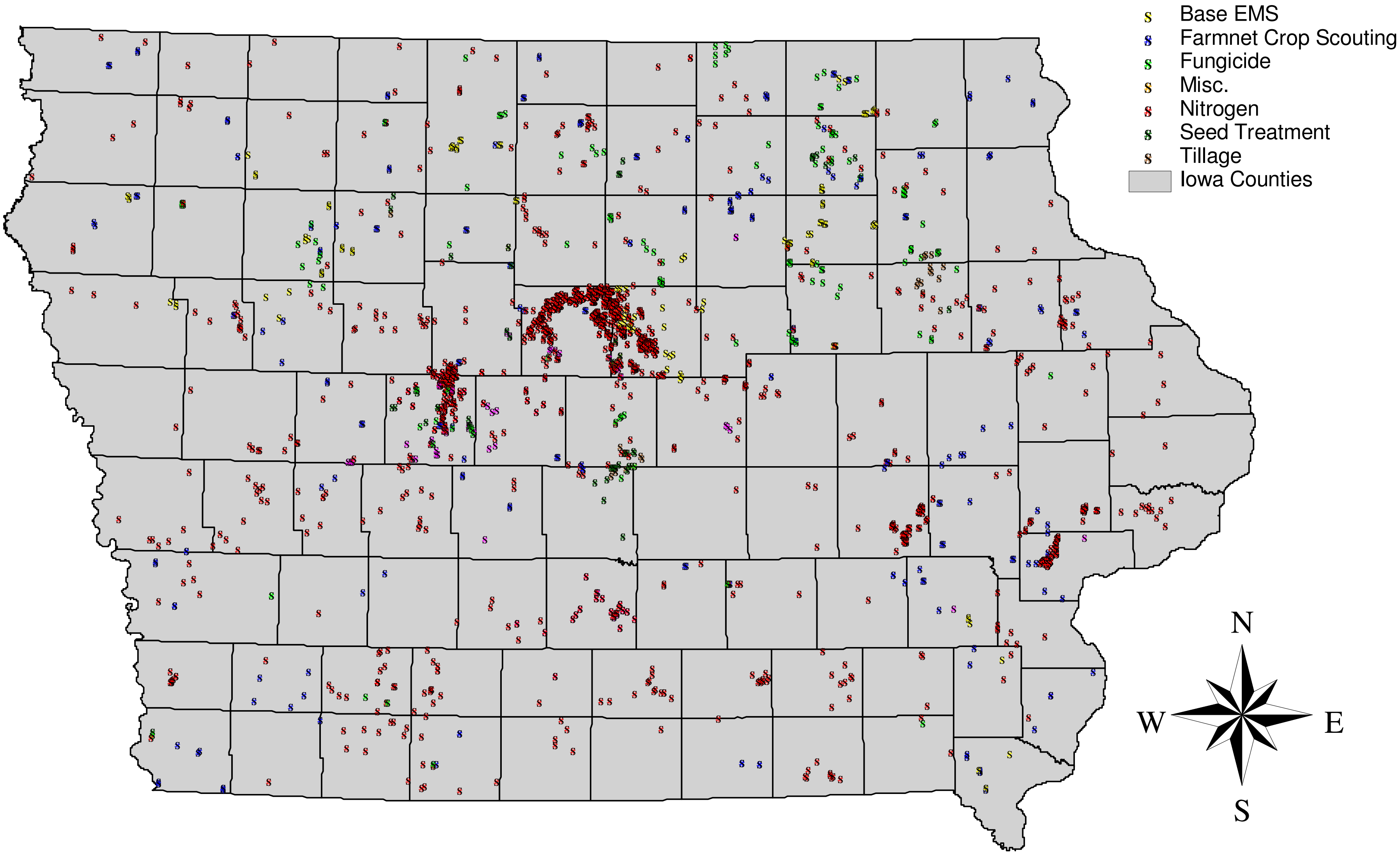
Because of the light soils and high percentage of liquid N applied, significant loss occurred in some locations. There were very few fields receiving fall application. Because of the soil composition, these fields are more likely to become water stressed, which greatly impacts both grain yield and nitrogen requirements.

Future testing on preventing loss on the sandy soils would be a reasonable focus. Already, most growers are not applying fall N on the sandy soils.

Partners

Iowa Soybean Association
Muscatine County Soil and Water Conservation District
Natural Resources Conservation Service
The Nature Conservancy
University of Iowa Hygienic Laboratory
United States Environmental Protection Agency
Iowa Dept. of Agriculture and Land Stewardship (Integrated Farm and Livestock Management Program)
Iowa State University

2005 ISA On-Farm Network™



Replicated strip testing

Brief description

Replicated strip testing is a methodology of comparing the yields of two different management practices across a field. These strips of alternating N management practices are harvested with combines equipped with GPS and yield monitors. Management practices may focus on differences in rate, timing, and source of N.

Guidelines on replicated strip testing

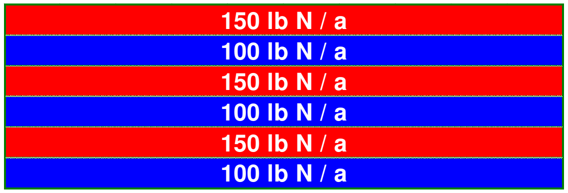
The basic premises for replicated trials used in the Iowa Soybean Association On-Farm Network™ studies are:

1. Keep it simple, just compare two management practices in a given trial.

2. Keep all other practices the same (i.e., same hybrid, seed treatment, planting date).

3. Replicate it at least 3 times, in side-by-side strips across the field at least the width of your combine header. More replications are better.

4. For N rate differences, 50 lb N/a difference is recommended. If a smaller difference is used, more replications are needed.



Selecting a field

Unlike small plot research, field variability can make a trial more valuable. Because GPS and yield monitors permit yield measurements in site-specific places, a single trial could characterize a number of different soil types or landscape positions.

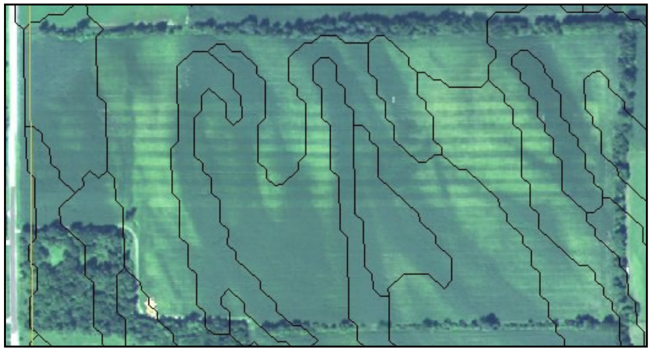
Fields that have significant soil or landscape variation that lays perpendicular to the treatments are preferred. This way both treatments are affected relatively the same.

Fields with frequent terraces or point rows make it difficult to compare side by side passes making such fields less suitable for strip testing.

Types of comparison

While there are many different types of comparisons that can be done, here is a list of some of the most popular N trials:

- •Normal N rate vs. normal N rate-50 lbs (shown in bottom left figure using a normal rate of 150 lb N/a)
- •Sidedressing 75 lbs. of N vs. 125 lbs N for corn following soybeans
- •Fall vs. spring application of N
- •Manure + 50 lb N/a
- •Manure equivalency for N
- •Nitrogen product comparisons such as UAN vs. anhydrous ammonia
- •Application method comparisons such as broadcast vs. incorporated N



Above is an example of an aerial image of a strip test with two different rates of N. The black lines are the soil map units.

Soil Name	Label	% of Field	140# N Yield (bu/a)	Soil Name	Label	% of Field	110# N Yield (bu/a)	Yield Difference
Sparta	41	5.8	109.1	Sparta	41	5.4	62.6	46.5
Sparta	41B	8.5	119.7	Sparta	41B	8.0	82.1	37.6
Ankeny	136	5.2	160.1	Ankeny	136	5.8	131.6	28.5
Watseka	141	18.9	141.9	Watseka	141	19.6	102.6	39.3
Bolan	174	1.4	142.4	Bolan	174	1.1	102.3	40.1
Dickinson	175	3.8	178.8	Dickinson	175	3.1	161.6	17.2
Dickinson	175B	1.2	165.0	Dickinson	175B	1.9	149.4	15.6
Kennebec	212	1.9	177.4	Kennebec	212	1.9	154.3	23.1
Pillot	450B	0.9	186.1	Pillot	450B	0.9	163.0	23.1
Spillville	485	2.4	180.7	Spillville	485	2.2	156.3	24.4

	140#	110#
Average Yield (Bu/a):	143.6	109.3

Yield Difference: 34.3 bu/a

Yield summaries

From the yields of each strip, the average yield difference for each N rate is easy to calculate. In addition, both yields and difference in yields between N management practices can be calculated for each soil type as shown in the above summary comparing replicated strips of 140 lbs. of N to 110 lbs. of N.

The late-spring test for soil nitrate: what the test can and cannot do

Background information

The late-spring test for soil nitrate is a tool that enables producers to estimate amount of available N in the soil before corn plants start intensively taking up this N. The test was developed specifically for conditions in Iowa where crop producers apply much or all of N fertilizer to corn before planting and losses of this N often occur after heavy spring rainfalls. Soil test values measured by the test were calibrated in numerous field studies for a probability of yield response to applied N at different soil test categories.

Despite the wealth of information collected over more than two decades of using the late-spring nitrate test in Iowa, producers constantly ask many questions how to use the soil-nitrate test in specific conditions and for different crop categories.

The objective of this poster is to reinstate major points to what the late-spring soil nitrate test can and cannot do when it is used to guide N fertilization practices for corn in Iowa.

Critical concentration

The critical concentration of 25 ppm of soil nitrate in the surface foot-layer of soil separates soil test categories where fertilizer N is profitable and not profitable to apply. High probability of yield response is observed below 25 ppm of nitrate-N and low probability is observed above 25 ppm of nitrate-N.

Time of sampling

The time of sampling is selected in late May to early June when corn plants are 6 to 12 in. tall to address effects of spring rainfalls and effects of mineralization of soil organic matter on concentration of soil nitrate in the surface-foot layer of the soils.

Is it enough to sample soils to a foot depth?

Although soil nitrate-N is highly mobile within the soil profile, benefits of sampling deeper than one foot are insignificant. Soil nitrate below this depth (deeper than 1 ft.) is likely to be lost during May and June rainfall events and, therefore, will not be available for corn plants.

Should soil exchangeable ammonium be included?

Previous studies had shown that including soil exchangeable ammonium in the test did not significantly improve ability of the test to predict yield responses to applied N. When most of fertilizer N is applied in fall or early spring before planting, concentrations of exchangeable ammonium are relatively low because of rapid nitrification of fertilizer N. However, concentrations of exchangeable ammonium can be high when high rates (higher than optimal) of anhydrous ammonia and manure are applied and when nitrification inhibitors are used. In these situations, the soil test values should be interpreted with caution.

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Soil that received animal manure

For soils that received applications of animal manure, the critical soil nitrate concentration is only 11-15 ppm because additional amounts of available N can potentially come from mineralization of organic N of the manure after the time of soil sampling. Another reason to lower the critical concentration for these soils is to make adjustments for possible high exchangeable ammonium concentrations. Using the lower critical values will avoid unnecessary applications of fertilizer N.

The late-spring nitrate test is always recommended when producers suspect losses of N from applied animal manure, by leaching or denitrification, and when producers suspect high losses of this N by ammonia volatilization as a result of inefficient manure application practices.

Soil fertilized with anhydrous ammonia in spring

Similar to the soils that received animal manure, the critical soil nitrate concentration for soil fertilized with spring anhydrous ammonia just before planting is also in a range of 11 to 15 ppm. The lower critical nitrate concentration is needed because such soils can have considerable amounts of exchangeable ammonium. Higher than usual concentration of exchangeable ammonium will likely occur when nitrification of N applied as anhydrous ammonia is partially retarded by using inhibitors of nitrification and when N rates higher than 150 lb N/acre of anhydrous ammonia are applied in spring.

Does the test work to guide sidedressed N?

For producers who rely solely on applying most N sidedressed as either UAN or anhydrous ammonia, the late soil nitrate test has little value. It is not recommended in this situation, because soil nitrate concentrations are usually low when corn plants are 6-8 inches tall and therefore soil nitrate concentrations are mostly affected by soil organic matter content.

Effects of weather on the critical concentration

Because nitrate is highly mobile within the soil, soil nitrate concentrations are affected by the amount of rainfall occurring before soil sampling. When soil samples are collected during 2-3 days after the rain, the critical concentrations will be lowered by 3-5 ppm. Also, the critical soil nitrate concentration will be lowered after excessive amounts of rainfall before soil sampling for soils that received animal manure and anhydrous ammonia applications.

Excessive rainfall before sampling also causes high spatial variability in soil test values due to high spatial variability in losses of fertilizer N within fields.

Economic considerations

Producers must always weigh losses and benefits when soil test values call for applications of extra N to avoid N deficiency in corn. A good strategy is always to consider grain and fertilizer prices as well as cost of fertilizer applications.

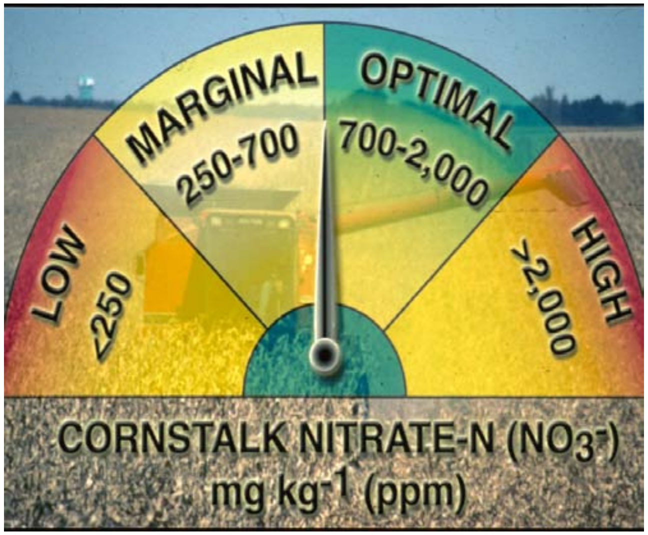
End-of-season stalk nitrate test

Brief description

The end-of-season stalk nitrate test is a tool that can be used to evaluate the availability of N to the corn crop. Nitrate concentrations measured from stalk sections from the lower portion of a corn plant taken after physiological maturity are indicative of N availability to the plant.

Why this test works

During most of the season, the corn plant acts as a factory to produce grain. Taking up N during most of the season then moving that N into the grain is the first priority of the corn plant. By measuring the amount of N that was left after grain fill, a determination can be made as too how much “extra” N was left in the plant above what was needed for optimal grain yield.



How to collect the samples

After the corn has reached physiological maturity, stalk samples can be collected. Sampling the correct location on the plant is critical. Eight inch sections, 6-14” above the ground should be collected with the sheaths/leaves and any dirt removed from the samples.

Depending on how the samples are to be used to represent a given location or a field, at least 10 stalks should be combined for a single sample. Plants that are damaged or barren should not be sampled. It is best to pick a number like 5, start counting consecutive plants and sample the 5th plant if it is not barren, damaged, a skip or a double planted.

For a post season assessment

For an initial review of what happened last season, an interpretation of the stalk values is needed for each sampling point. Following are the four categories for interpretation, as defined in ISU Pm-1584:

Class	Nitrate Concentration (ppm Nitrate-N)	Interpretation
Low	<250	High probability that greater availability of N would have increased yields
Marginal	250-700	Slightly lower than economic thresholds
Optimal	700-2000	High probability that N availability was within the range to maximize profits
Excess	>2000	High probability that N availability was greater than N applied at economic optimal rates (More N was available than needed for optimal profit)

Collecting stalk samples after harvest

Collecting stalk samples after a field has been combined is not generally recommended for three main reasons.

1. Most combines don’t leave enough stalk for correct stalk sampling position.
2. After harvest you can’t determine if it was damaged or barren.
3. Rainfall on stalks after harvest can significantly lower nitrate concentrations

Effects of rainfall on stalk nitrate values

Nitrate concentration in a given corn crop can vary. This variation is because the N availability and use by a crop is affected by amounts of rainfall. Drought years will have higher values because there is less N loss, more N availability and less grain production. Wet years can result in lower values because of higher N losses that reduce N availability. In either case, the test is valuable because it accurately assesses what happened to the crop.

Hybrid variation on test readings

Hybrids vary in their ability to take up N and their ability to produce grain. Stalk nitrate concentration is therefore affected, but still indicative of what the plant had available. The databases used to calibrate this test and continually verify its calibration have consisted of many hybrids and have shown hybrid differences are minor compared to normal variability in management and spatial variability.

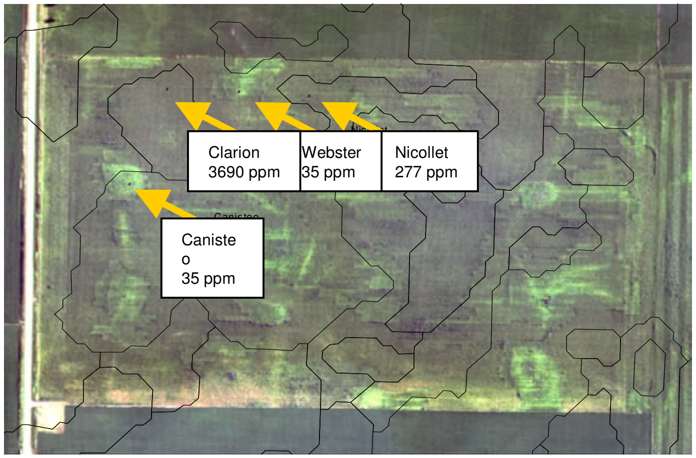
Guided stalk nitrate sampling

Brief description

The end-of-season stalk nitrate test is a tool that can be used to evaluate the availability of N to the corn crop. Because most fields are not uniform, consideration of where the samples should be collected is important. Guided stalk nitrate sampling is a method used to determine where to collect multiple samples that can be used to evaluate a field.

Why a guided approach is needed

In many parts of Iowa, N availability can vary more within a 20-acre area than between the average of two different 20-acre areas. Unlike phosphorus or potash, nitrogen deficiency is easily detected by normal remote sensing. Combining the power of remote sensing with soil survey information makes it possible to characterize differences in the field that are likely to change the N availability to the corn crop.



How the points are selected

In a typical field, we try to select four different sampling locations. One sampling location is based upon the color image trying to capture a location that looks deficient. The other three sampling locations are guided by the soil map units. One sample is collected from each of the three dominant soil map units in the field. This pre-selection of varying soil map units will help reflect any N differences caused by soil variability.

Tools available for point selection

Tools include remote sensing, GPS, and GIS mapping software. Computers with GIS make it easy to use aerial imagery and digitized soil surveys to pick the four sampling locations. Iowa is very fortunate to have all of their soil survey images available free on the internet at http://icss.agron.iastate.edu/. In addition, various sources of georeferenced imagery (images with known location points) are available.

In addition to GIS programs, hand held GPS units are now common with ag service providers. Most ag service providers can load GPS points onto handheld units and use them to find their sampling location in the field.

Special stalk samplers that cut the 8-in. sections precisely 6 in. above the ground as recommended can be used to collect individual samples. The student to the right is using such a sampler that was manufactured by some Jefferson-Scranton FFA students.

Picking points without imagery

There is considerable value in a late August/early September image of the cornfield to guide where to sample. Unfortunately, it is not always possible to obtain such an image. In such circumstances, selecting three points based on soil map units is recommended. Other imagery such as the digital orthoquads (DOQs) can provide assistance in identifying soil differences such as soil organic matter. DOQs from 1990-2000, color Infrared DOQs from the spring of 2002, color orthophotos from 2004 and 2005 are all available at http://ortho.gis.iastate.edu/.

Evaluating over time

Consideration of rainfall data is critical. For the best results, tracking a subset of a grower's fields that represent the different management practices and types of soils over a number of years is recommended.

Impacts of reducing rates of spring-applied N by 50 pounds per acre for corn in Iowa

Problem addressed

Iowa corn producers need reliable estimates of the economic and environmental impacts of reducing rates of N fertilization. This information is needed to address narrowing profit margins and mounting concerns about losses of N from fields to rivers. Instead of assuming all fields across Iowa need the same amount of N, this test let growers account for their own experience and management practices and test the rate they use on their farm.

What was done

Corn producers at 143 sites compared their normal rate of N application to 50 lb N/acre less in replicated two-treatment precision farming trials that covered at least 20 acres. The fertilizer N usually was applied shortly before or after planting. All fields were corn grown after soybean.

What were the impacts?

Producers who usually attain yields less than 200 bu/acre, especially if applying anhydrous ammonia (NH_3), could reduce rates of N application by 50 lb N/acre without loss of profit. The mean difference in yields across all trials was approximately equal to the cost of the extra fertilizer N applied.

Reducing rates of N application by 50 lb N/acre reduced the amounts of N harvested in grain by 3 lb N/acre and the amounts that can be lost to the environment by 47 lb N/acre.

The higher rate of N fertilization usually was more profitable when yields exceeded 200 bu/acre for both NH_3 and UAN. This rate was also more profitable when using UAN with yields less than 200 bu/acre.

Applying the extra fertilizer was profitable at some sites. These profits, however, can only be obtained if the responsive fields can be identified before fertilization.

Overall the UAN was more responsive to the extra N than the NH_3 by 3 bu/acre.

Summary of trials by form

	Fertilizer N		Yield	
Form	**Low Rate**	**High Rate**	**Low Rate**	**Response**
NH3	100	149	184	6
UAN	98	147	172	9
Mean	**100**	**149**	**178**	**8**

Summary of trials by year

Year	March - May Rainfall	Fertilizer N Low Rate	Fertilizer N High Rate	Yield Low Rate	Yield Response
	----- in -----	----- lb N/acre -----		----- bu/acre -----	
2000	7.5	119	169	157	2
2001	11.3	102	152	169	3
2002	8.5	96	148	189	7
2003	9.8	98	153	179	4
2004	14.4	99	143	195	13
2005	8.6	95	147	177	8
Mean	**10.8**	**100**	**149**	**178**	**8**

Summary of trials by form and 2 yield levels

Form	Category	Fertilizer N Low Rate	Fertilizer N High Rate	Yield Low Rate	Yield Response
		----- lb N $acre^{-1}$ -----		----- bu $acre^{-1}$ -----	
NH3	<200	97	147	172	4.7
	>200	105	152	202	9.0
UAN	<200	99	148	162	8.8
	>200	97	144	199	11.4
Mean	**<200**	**99**	**148**	**167**	**6.3**
	>200	**102**	**149**	**201**	**10.1**

Other observations

The mean "normal" rate of N applied by the producers was only 81% of the mean rate normally called for by recommendations based on "yield goals and credits". If it is assumed that the lower rate was the most profitable rate for producers attaining less than 200 bu/acre and the higher rate was more profitable for producers attaining higher yields, **the mean most profitable rate of fertilization was only 63% of the rate normally called for by recommendations based on "yield goals and credits".**

Conclusions

Most producers who participated in this study could have reduced N rates by 50 lb N/acre with no loss of profit. Programs designed to *help producers learn* where rates of N application can be profitably reduced should greatly reduce concentrations of nitrate in Iowa rivers and increase the profitability and competitiveness of Iowa agriculture.

Summary of spring N +/- 50 lb N/acre

		March - May	Fertilizer N[1]			Yield	
County	Year	Rainfall	Low Rate	High Rate	Form	Low Rate	High Rate
		----- in -----	----- lb N $acre^{-1}$ -----			------- bu $acre^{-1}$ -------	
Hamilton	2005	8.1	90	140	UAN	128	132
Muscatine	2005	6.1	130	180	UAN	135	136
Howard	2001	12.1	100	130	Urea	135	137
Chickasaw	2002	9.5	117	167	UAN	142	141
Grundy	2001	10.3	146	206	UAN	140	141
Muscatine	2004	13.9	110	140	UAN	109	144
Grundy	2001	10.3	80	130	UAN	144	145
Buchanan	2000	7.3	100	150	NH3	146	146
Floyd	2000	8.0	100	150	UAN	147	148
Buchanan	2000	7.3	140	190	NH3	146	149
Black Hawk	2003	9.5	60	120	NH3	145	150
Black Hawk	2002	6.9	60	110	NH3	145	150
Buena Vista	2001	11.4	75	125	UAN	150	152
Greene	2001	12.0	110	160	NH3	149	153
Chickasaw	2001	11.0	85	145	UAN	146	153
Hamilton	2005	8.1	90	140	UAN	155	154
Cerro Gordo	2001	13.1	120	170	NH3	158	155
Buchanan	2000	7.3	100	150	NH3	156	156
Howard	2004	17.4	60	110	UAN	143	156
Black Hawk	2004	13.0	55	105	NH3	132	156
Black Hawk	2004	13.0	55	105	NH3	134	156
Palo Alto	2001	11.8	91	141	Urea	154	159
Buchanan	2000	7.3	130	180	NH3	155	159
Howard	2004	17.4	100	145	UAN	154	160
Chickasaw	2001	11.0	80	130	Urea	148	160
Palo Alto	2002	7.6	80	130	UAN	156	162
Franklin	2001	13.3	100	150	UAN	153	162
Ringgold	2005	9.0	120	170	UAN	149	162
Floyd	2001	11.9	110	160	NH3	161	162
Bremer	2001	10.7	100	139	UAN	159	164
Chickasaw	2003	11.9	67	127	UAN	159	164
Cerro Gordo	2000	7.3	100	150	UAN	158	165
Franklin	2000	8.1	130	180	UAN	163	165
Delaware	2001	9.8	75	125	NH3	166	166
Story	2003	10.4	130	180	NH3	167	166
Chickasaw	2001	11.0	130	180	Urea	164	167
Story	2001	12.4	120	170	Urea	165	167
Howard	2004	17.4	60	110	UAN	133	168
Muscatine[2]	2005	6.1	110	160	UAN	166	170
Story	2001	12.4	130	180	Urea	172	171
Story	2001	12.4	135	185	Urea	170	172
Hamilton	2005	8.1	90	140	UAN	169	172
Howard	2005	7.2	90	125	UAN	166	173
Howard	2005	7.2	60	125	UAN	135	173
Grundy	2002	8.2	79	129	UAN	169	173
Palo Alto	2003	8.9	80	130	Urea	171	173
Black Hawk	2003	9.5	110	157	NH3	168	175
Clay	2002	7.2	100	200	Urea	170	175
Buchanan	2001	10.5	86	136	NH3	170	176
Hardin	2004	14.3	145	185	NH3	178	177
Boone	2001	12.4	100	150	NH3	174	177
Chickasaw	2005	8.8	75	125	UAN	174	178
Hancock	2005	14.4	118	193	UAN	163	178
Black Hawk	2001	8.6	116	166	NH3	176	178
Hardin	2004	14.3	145	185	NH3	172	178
Buchanan	2001	10.5	70	125	Urea	175	179
Linn	2003	8.7	100	150	NH3	177	179
Boone	2005	14.4	100	125	UAN	171	179
Story	2003	10.4	130	180	NH3	180	181
Buchanan	2002	9.4	75	125	NH3	174	182
Buchanan	2000	7.3	150	200	NH3	182	183
Washington[2]	2004	12.9	80	150	NH3	162	183
Boone	2001	12.4	100	150	NH3	180	183
Delaware	2001	9.8	120	170	UAN	183	184
Buchanan	2001	10.5	105	155	NH3	179	184
Palo Alto	2005	9.8	70	120	UAN	184	185
Hardin	2005	10.3	80	130	NH3	187	185
Hamilton	2005	8.1	80	130	NH3	173	186
Bremer[2]	2001	10.7	115	165	NH3	183	186
Polk	2002	8.2	100	150	NH3	187	186
Black Hawk[2]	2005	7.0	55	105	NH3	159	187
Washington[2]	2001	16.1	102	154	UAN	179	188
Boone	2004	14.4	125	150	NH3	181	188
Cerro Gordo	2002	6.4	75	125	NH3	187	188
Webster	2005	7.5	75	125	NH3	190	189
Greene	2004	14.4	100	150	UAN	169	189
Cerro Gordo	2005	12.5	75	125	NH3	188	190
Bremer	2001	10.7	90	135	NH3	192	190
Greene[2]	2004	14.4	131	181	UAN	172	190
Lee	2004	11.5	154	204	UAN	174	191
Boone	2004	14.4	75	125	UAN	190	192
Hardin	2002	8.4	95	145	NH3	187	193
Black Hawk	2002	6.9	75	125	NH3	192	193
Black Hawk	2001	8.6	80	130	NH3	188	193
Johnson	2002	10.5	130	180	UAN	195	193
Floyd	2002	8.1	100	150	Urea	192	194
Hardin	2002	8.4	95	145	NH3	193	194
Boone	2004	14.4	100	125	UAN	191	195
Black Hawk	2002	6.9	105	155	NH3	193	195
Webster	2005	7.5	75	125	NH3	188	196
Story	2004	14.4	125	185	UAN	178	196
Boone	2004	14.4	120	160	UAN	186	197
Bremer[2]	2002	7.8	115	165	NH3	191	197
Howard	2002	6.7	85	125	UAN	188	198
Tama	2002	6.9	75	125	NH3	194	199
Chickasaw	2002	9.5	67	127	UAN	183	199
Greene[2]	2004	14.4	110	160	UAN	188	199
Buchanan	2001	10.5	90	140	NH3	199	200
Hamilton	2005	8.1	100	150	NH3	191	201
Greene[2]	2004	14.4	110	160	UAN	183	201
Hardin	2002	8.4	95	145	NH3	199	202
Boone	2004	14.4	100	125	UAN	204	204
Buchanan	2001	10.5	105	155	NH3	199	204
Boone	2004	14.4	125	150	NH3	186	204
Palo Alto	2004	12.5	80	120	UAN	204	204
Palo Alto	2003	8.9	75	150	NH3	191	204
Grundy	2002	8.2	80	125	NH3	200	204
Boone	2004	14.4	70	120	NH3	185	204
Boone	2004	14.4	125	165	UAN	203	205
Hardin	2004	14.3	85	135	NH3	196	205
Hamilton	2005	8.1	150	200	NH3	201	206
Bremer	2002	7.8	112	162	NH3	205	206
Chickasaw	2005	8.8	75	125	UAN	206	206
Hardin	2004	14.3	85	135	NH3	200	206
Chickasaw	2004	16.8	75	125	UAN	184	206
Chickasaw	2004	16.8	75	125	UAN	184	206
Hardin	2004	14.3	85	135	NH3	206	207
Keokuk[2]	2005	6.2	110	160	UAN	199	207
Howard	2002	6.7	85	125	UAN	200	207
Story	2005	9.0	135	185	NH3	202	207
Greene[2]	2004	14.4	75	125	UAN	191	208
Story	2002	9.2	75	140	Urea	182	208
Story	2002	9.2	146	196	NH3	204	209
Boone	2004	14.4	125	150	NH3	204	210
Pottawattamie	2004	14.5	80	130	UAN	164	211
Hardin	2004	14.3	85	135	NH3	207	212
Hancock	2005	14.4	118	193	UAN	197	214
Story	2002	9.2	146	196	NH3	211	214
Hardin	2004	14.3	85	135	NH3	210	215
Black Hawk	2004	13.0	100	130	NH3	207	215
Bremer	2004	17.4	115	165	NH3	208	215
Marshall[2]	2002	7.1	43	83	NH3	198	217
Black Hawk	2004	13.0	115	145	NH3	197	218
Blackhawk	2004	13.0	115	145	NH3	198	218
Story	2003	10.4	130	180	NH3	213	218
Boone	2004	14.4	125	165	UAN	210	218
Washington[2]	2002	13.2	115	170	NH3	190	220
Story	2002	9.2	146	196	NH3	221	222
Hardin	2004	14.3	85	135	NH3	217	224
Washington[2]	2002	13.2	115	170	NH3	205	225
Buchanan	2002	9.4	106	156	NH3	217	225
Chickasaw	2001	11.0	105	155	UAN	227	229
Mahaska[2]	2005	6.6	110	160	UAN	233	234
Mean		**11**	**100**	**149**		**178**	**186**

[1] Any nitrogen applied with P is included in rate at nearly all sites.

[2] Nitrogen applied after crop emerged.

Is 100 lb/acre of fertilizer N enough for corn following soybean in Iowa?

Background

Recent research indicates that 100 lb N/acre may be adequate for corn following soybean in Iowa ***if*** application is delayed until late May or early June to minimize losses of the N during rainfall before plants grow.

This possibility deserves attention because 100 lb N/acre is enough to replace the amount of N removed by a 200 bu/acre corn crop (0.7 lb N/bu) if 40 lb N/acre "fertilizer-N credit" is given for soybean.

What was done

This possibility was evaluated in 59 two-treatment precision farming trials over 6 years. Corn producers applied about 75 and 125 lb N/acre in alternating strips across 10 to 20 acres in their fields. Crop responses to the higher N rate were evaluated by remote sensing of the crops and measuring yields at the end of the season.

What was found

For fields yielding <200 bu/acre

The mean yield increase (6 bu/acre) produced by increasing N rate was enough only to pay for the extra fertilizer. (It *usually takes about 4 bu to buy 50 lb of N, but it may take 6 bu in 2004 and 2005.)*

Because two thirds of this yield increase would be expected when N rates are increased from 75 to 100 lb N/acre, the 100 lb N/acre rate would have essentially maximized profits.

The higher rate was profitable at selected sites, but this profit can be obtained *only if* the responsive sites can be identified *before* fertilization.

For fields yielding >200 bu/acre

The increase in rate would have been profitable. This profit can be obtained, however, only if these fields can be identified before fertilizers are applied. *At sites where this yield level is often attained, 2-treatment trials should be conducted with 100 and 125 lb N.*

Summary of trials by year

Year	March - May Rainfall	Fertilizer N		Yield	
		Low Rate	High Rate	Low Rate	Response
	----- in -----	----- lb N acre^{-1} -----		----- bu acre^{-1} -----	
2000	8.1	80	123	182	5
2001	11.9	78	123	165	5
2002	8.2	79	128	159	4
2003	9.9	79	131	173	2
2004	14.7	75	125	181	14
2005	9.9	80	130	180	11

Mean yield responses for corn at 2 yield levels.

Yield level*	Yield	
	Mean*	Response
	------------------ bu/acre ------------------	
> 200	211	12
< 200	171	6

* Yields at high N rate.

Other findings (not shown)

Spatial patterns in response within fields indicated that the optimal rate of N often varied with position in fields (landscape position/soil organic matter content). Analysis of these spatial patterns should help predict where the higher rates of fertilization will be profitable in the future.

Conclusions

Fertilization at a rate of 100 lb N/acre usually is adequate to maximize profits for corn grown after soybean in Iowa if application is delayed until after the crop has emerged.

The two-treatment precision farming trials provide an efficient way to identify where higher rates of N application are likely to be profitable.

Use of the two-treatment precision farming trials should help corn producers increase their profits while substantially reducing losses of N to the environment.

Summary of 75/125 N-rate comparisons[1]

Year	County	March - May Rainfall	Fertilizer N		Yield	
			Low Rate	High Rate	Low Rate	High Rate
		----- in -----	-------- lb N/acre --------		-------- bu/acre --------	
2000	Buchanan	7.3	80	110	144	147
2000	Clinton[2]	7.3	80	130	184	197
2000	Louisa[2]	9.7	80	130	218	216
2001	Boone	12.4	75	125	133	138
2001	Dallas[2]	10.6	75	125	137	139
2001	Boone	12.4	75	125	144	148
2001	Lucas	12.9	75	125	146	156
2001	Story	12.4	75	125	147	158
2001	Black Hawk	8.6	70	120	163	168
2001	Mitchell[2]	14.3	85	110	170	170
2001	Marshall[2]	10.5	80	130	172	175
2001	Floyd	11.9	75	125	170	178
2001	Buchanan[2]	10.5	93	128	185	184
2001	Buchanan[2]	10.5	80	110	180	188
2001	Washington[2]	16.1	80	130	229	234
2002	Osceola	6.3	75	125	128	136
2002	Dallas	8.7	86	136	135	136
2002	Sioux	6.0	75	125	142	144
2002	Sioux	6.0	75	125	148	150
2002	Chickasaw[2]	9.5	90	140	149	152
2002	Sioux	6.0	75	125	161	159
2002	Osceola	6.3	67	117	155	163
2002	Greene	11.3	75	125	160	163
2002	Carroll[2]	9.0	80	135	166	170
2002	Greene	11.3	75	125	174	178
2002	Greene	11.3	75	125	186	192
2002	Buchanan[2]	9.4	95	145	209	214
2002	Osceola	6.3	67	117	155	163
2003	Boone	10.4	75	125	186	191
2003	Boone	10.4	75	125	194	196
2003	Boone	10.4	75	125	185	190
2003	Bremer	10.9	82	132	138	139
2003	Sioux[2]	8.6	83	137	170	169
2003	Sioux[2]	8.6	83	137	167	165
2004	Greene	14.4	70	120	184	192
2004	Greene	14.4	70	120	187	200
2004	Greene	14.4	75	125	183	202
2004	Greene	14.4	75	125	188	200
2004	Greene	14.4	75	125	189	207
2004	Hamilton	15.7	75	125	166	189
2004	Hamilton	15.7	75	125	177	192
2004	Greene	14.4	75	125	163	181
2004	Fremont	14.8	65	115	172	176
2004	Black Hawk	13.0	70	120	196	219
2004	Chickasaw[2]	16.8	95	145	175	191
2004	Story	14.4	80	130	195	196
2004	Greene	14.4	75	125	184	197
2005	Mitchell[2]	10.8	80	130	182	192
2005	Mitchell[2]	10.8	80	130	153	162
2005	Hancock	14.4	75	125	174	180
2005	Hancock	14.4	75	125	170	169
2005	Chickasaw	8.8	75	125	188	204
2005	Chickasaw	8.8	75	125	189	202
2005	Chickasaw[2]	8.8	95	145	178	194
2005	Mitchell	10.8	80	130	180	193
2005	Buchanan[2]	6.8	87	137	173	179
2005	Floyd	8.2	97	147	160	172
2005	Buchanan	6.8	70	110	200	212
2005	Story	9.0	75	125	209	223
	Mean	**11**	**78**	**127**	**172**	**179**

[1] Some trials initially put in the "75/125" trials were moved to "-50/+50" trials because rates were not close enough to 75 and 125 lb N/acre.

[2] 3-30 lb N/acre applied as starter at planting included in rate.

An analysis of optimal sidedressing N rates for corn following soybean

Explanation

With new analytical tools, it is now possible to calculate an optimum N rate based on the two-treatment trials. The table to the right is the same data as presented previously with the optimal N rate provided based upon four different pricing scenarios.

What was done

The N calculator that uses discrete marginal products analysis was applied to all the 75/125 sites that had the appropriate range of yield response between the two treatments. The corn price used was $2.00/bu and scenarios for both $0.20/lb N and $0.40/lb N are reported in the table to the right.

What was found

To obtain a 10% profit, the average optimal N rate was 109 lb N/acre based upon $0.20/lb N and $2.00/bu corn. The price of N has a major impact on the optimal rate as demonstrated by the 55 lb N/acre difference based on the $0.40/lb N scenario that currently exists.

Other points

When compared to spring applied N (mostly preplant), the same price scenarios of $0.20/ lb N and $2.00/bu corn were only 4 lb N/acre more than those observed in the sidedressing rates.

The more trials that growers collect, the more ability there is to identify scenarios that are more or less profitable. With enough growers conducting trials, it will be possible to compare many different management practices in many different areas.

Growers are the only ones that can collect this amount of data and growers have the most to gain.

About the calculator

More information about the calculator and how to use it are provided on pages C4-C6 in this handout.

Summary of 75/125 N-rate comparisons[1]

		March - May	**Fertilizer N**		**Yield**		**$0.20 Fertilizer N**		**$0.40 Fertilizer N**	
Year	**County**	**Rainfall**	**Low Rate**	**High Rate**	**Low Rate**	**High Rate**	**Break Even**	**10% Profit**	**Break Even**	**10% Profit**
		----- in -----	-------- lb N/acre --------		-------- bu/acre --------		-------- lb N/acre --------		-------- lb N/acre --------	
2000	Buchanan	7.3	80	110	144	147	95	91	51	42
2000	Clinton[2]	7.3	80	130	184	197	148	145	121	116
2000	Louisa[2]	9.7	80	130	218	216	-	-	-	-
2001	Boone	12.4	75	125	133	138	100	93	27	12
2001	Dallas[2]	10.6	75	125	137	139	56	49	0	0
2001	Boone	12.4	75	125	144	148	85	78	12	0
2001	Lucas	12.9	75	125	146	156	127	124	100	95
2001	Story	12.4	75	125	147	158	132	129	105	100
2001	Black Hawk	8.6	70	120	163	168	95	88	22	7
2001	Mitchell[2]	14.3	85	110	170	170	-	-	-	-
2001	Marshall[2]	10.5	80	130	172	175	76	68	3	0
2001	Floyd	11.9	75	125	170	178	144	137	71	56
2001	Buchanan[2]	10.5	93	128	185	184	-	-	-	-
2001	Buchanan[2]	10.5	80	110	180	188	168	164	124	115
2001	Washington[2]	16.1	80	130	229	234	105	98	32	17
2002	Osceola	6.3	75	125	128	136	144	137	71	56
2002	Dallas	8.7	86	136	135	136	53	45	0	0
2002	Sioux	6.0	75	125	142	144	56	49	0	0
2002	Sioux	6.0	75	125	148	150	56	49	0	0
2002	Chickasaw[2]	9.5	90	140	149	152	86	78	13	0
2002	Sioux	6.0	75	125	161	159	-	-	-	-
2002	Osceola	6.3	67	117	155	163	136	129	63	48
2002	Greene	11.3	75	125	160	163	71	63	0	0
2002	Carroll[2]	9.0	80	135	166	170	86	78	5	0
2002	Greene	11.3	75	125	174	178	85	78	12	0
2002	Greene	11.3	75	125	186	192	115	107	42	27
2002	Buchanan[2]	9.4	95	145	209	214	120	113	47	32
2002	Osceola	6.3	67	117	155	163	136	129	63	48
2003	Boone	10.4	75	125	186	191	100	93	27	12
2003	Boone	10.4	75	125	194	196	56	49	0	0
2003	Boone	10.4	75	125	185	190	100	93	27	12
2003	Bremer	10.9	82	132	138	139	49	41	0	0
2003	Sioux[2]	8.6	83	137	170	169	-	-	-	-
2003	Sioux[2]	8.6	83	137	167	165	-	-	-	-
2004	Greene	14.4	70	120	184	192	138	131	65	50
2004	Greene	14.4	70	120	187	200	136	133	109	103
2004	Greene	14.4	75	125	183	202	-	-	-	-
2004	Greene	14.4	75	125	188	200	138	135	111	106
2004	Greene	14.4	75	125	189	207	-	-	-	-
2004	Hamilton	15.7	75	125	166	189	-	-	-	-
2004	Hamilton	15.7	75	125	177	192	158	156	132	126
2004	Greene	14.4	75	125	163	181	-	-	-	-
2004	Fremont	14.8	65	115	172	176	70	62	0	0
2004	Black Hawk	13.0	70	120	196	219	-	-	-	-
2004	Chickasaw[2]	16.8	95	145	175	191	178	176	152	146
2004	Story	14.4	80	130	195	196	51	44	0	0
2004	Greene	14.4	75	125	184	197	140	137	113	107
2005	Mitchell[2]	10.8	80	130	182	192	131	128	104	99
2005	Mitchell[2]	10.8	80	130	153	162	126	124	100	94
2005	Hancock	14.4	75	125	174	180	119	112	46	31
2005	Hancock	14.4	75	125	170	169	-	-	-	-
2005	Chickasaw	8.8	75	125	188	204	157	154	130	125
2005	Chickasaw	8.8	75	125	189	202	146	143	119	114
2005	Chickasaw[2]	8.8	95	145	178	194	176	173	149	144
2005	Mitchell	10.8	80	130	180	193	150	147	123	118
2005	Buchanan[2]	6.8	87	137	173	179	125	117	52	37
2005	Floyd	8.2	97	147	160	172	164	161	137	132
2005	Buchanan	6.8	70	110	200	212	132	130	110	106
2005	Story	9.0	75	125	209	223	149	147	122	117
	Mean	**11**	**78**	**127**	**172**	**179**	**114**	**109**	**62**	**54**

[1] Some trials initially put in the "75/125" trials were moved to "-50/+50" trials because rates were not close enough to 75 and 125 lb N/acre.

[2] 3-30 lb N/acre applied as starter at planting included in rate.

Examples of “ultimate” two-treatment response trials

Background

For growers who know their optimal N rate or are willing to accept 100 lb N sidedressed after soybean as the optimal rate on a field scale, the next step is to apply 2 rates near the optimal rate that differ by 25 lbs on their entire farm. This will provide enough information about the spatial patterns occurring to define categories which can be used to define areas that vary in N fertilizer needs. Once adequately identified, variable-rate application or targeted monitoring can occur.

Problem addressed

The “ultimate” two-treatment response trial offers a novel way to refine estimates of N fertilizer needs for corn. It is assumed that producers who use precision farming technologies will be able to conduct these trials with minimal cost and effort in the near future.

The trials involve applying two near-optimal rates of N fertilization in alternating strips across large areas of soil. Yield differences are calculated in a fine-grid pattern to learn more about spatial patterns in optimal rates of N fertilization.

We have many studies illustrating that such trials could be done by using a 50 lb N/acre difference in rate of N fertilization. A key question is whether a difference as small as 25 lb N/acre can be used in these trials.

What was done

Fertilizer N was applied for corn after soybean at 100 and 125 lb N/acre in alternating 12-row or 16-row strips across large areas in each of 2 no-till fields in 2004 and 2 no-till and 2 ridge-till fields in 2005. The N was a 32% fertilizer solution injected about 8 inches from rows in the no-till field and NH_3 was injected in the ridge-till when plants were about 3 inches tall. No other N was applied to the field.

The fields were harvested with a 6-row or 8-row combine equipped with yield monitor and GPS. The yield data was processed using GIS to produce yield-response maps for square grid cells that were the width of the combine head. The yield-response maps were overlaid over soil survey maps to help relate spatial patterns in yield responses to landscape positions.

What was found

Classifying the yield-response maps by soil map units showed higher yield responses on areas with the greatest slopes within fields which usually correspond to the lowest soil organic matter content. It is important to note though that at several sites the Clarion and Webster soils had similar responses. These soils are very different, indicating a need for continued research to find a category which will provide stable spatial patterns in yield response.
The increase in rate was profitable for some categories but not others. (Note that it usually takes about 2 bu of grain to pay for 25 lbs of N).

Summary of Yield by Soil Map Unit

Year	Field	Soil Type	% Area	Yield 125 lb N	 100 lb N	Yield Response
				------------------ bu/acre	------------------	
2004	Site 1	Cordova	9	154	149	5
		Lester	5	154	149	5
		Clarion	34	169	166	4
		Webster	10	171	168	2
		Canisteo	35	172	171	1
		Nicollet	4	160	159	0
	Site 2	Nicollet	25	176	165	10
		Clarion	22	168	159	9
		Harps	18	180	172	8
		Webster	18	167	160	8
		Canisteo	14	184	178	6
		Knoke	5	190	188	2
2005	Site 1	Ottosen	37	201	200	1
		Brownton	33	208	208	0
		Kossuth	21	208	211	-3
		Okoboji	9	207	213	-5
	Site 2	Brownton	100	210	210	0
	Site 3	Clarion	49	120	115	5
		Webster	29	140	136	4
		Nicollet	23	132	127	4
	Site 4	Nicollet	8	174	168	6
		Webster	32	167	165	3
		Clarion	50	168	168	0
		Clarion-Storden Comp	10	171	172	-1

Comments

Because weather in 2004 resulted in yield responses that are greater than normal at most sites in Iowa, data collected in this year does not necessarily indicate that our estimate of the “economically optimal rate” is too low.
It could be argued that the effects of a 25 lb N/acre difference in rate of N fertilization are too small to measure. *If this argument is accepted, there is no basis for any claim that fertilizer recommendations can be estimated more precisely than the nearest 25 lb N/acre.*
When trials are conducted over many sites and years, small *mean* yield responses can be detected within any specified range of conditions. *The “ultimate” trials offer a high degree of precision that can be used to evaluate or develop N management guidelines for any group of fields studied.*

How does fall anhydrous compare to spring N?

Background

Past studies have shown that large losses of fall-applied anhydrous ammonia N can occur. A growing concern over high nitrate levels in Iowa rivers, mainly attributed to fall-applied anhydrous ammonia N, has increased interest in regulating or completely banning fall-applied anhydrous ammonia. Growers can evaluate the effectiveness of this management practice by using the two-treatment precision farming trials to compare fall-applied anhydrous ammonia N to spring-applied N.

What was done

Two-treatment trials were replicated at 36 sites that compared fall-applied anhydrous ammonia to spring-applied anhydrous ammonia or sidedressed UAN at the same rate. The trials covered 20 acres or more and all fields were corn after soybean. N-serve was used on some trials. Cornstalk samples were collected at some fields from each treatment in adjacent strips at three different test areas.

What was found

Both the fall-applied and the spring-applied N mean yield was 194 bu/acre across all sites. This means that if losses of N did occur they were not large enough to decrease yields more for the fall application than the spring.

The stalk nitrates showed that response should not be expected to the different time of application. There was a slightly greater percentage of the samples that fell in the low/marginal and optimal categories for the fall-applied-NH_3 than for spring N.

Summary of Stalk Nitrates

Source	Stalk Nitrate	Stalk Nitrate Categories Low/Marginal	 Optimal	 Excess
	ppm NO_3-N	--------------------	%	--------------------
Fall NH_3	2323	19	29	52
Spring N	2501	11	30	59

Other points

March through May rainfall, which has been shown to correlate with amount of nitrates in rivers, averaged 7.4 in across the sites. The 54 year average was 9.4 in for these sites, therefore, this year the March through May period was drier than normal. The same study also showed that a higher percentage of stalk nitrates were in the excess range in dry years. This is also seen here.

It is important to realize that this is only one year of data and without additional years it is impossible to determine how seasonal variation will affect the conclusions. This is illustrated in both the 75 vs. 125 and spring N +/- 50 trials. The first 4 years of these trials were non-responsive years, whereas 2004 and 2005 were responsive.

Conclusions

Most producers did not see any difference in yields between the fall-applied and spring-applied N.

These types of trials need to be conducted for several more years to account for the differences that occur during the growing season.

Summary of Fall vs Spring N trials

Year	County	March - May Rainfall	Timing	Rate	Grain Yield	Stalk Nitrate		
		----- in -----		-lb/acre -	- bu/acre -	--- ppm nitrate N ---		
2005	Humboldt	8.8	Fall	125	195			
			Spring	125	195			
2005	Humboldt	8.8	Fall	125	195			
			Spring	125	191			
2005	Greene	6.5	Fall	150	189			
			Spring	150	189			
2005	Boone	9.0	Fall	130	184	35	735	1180
			Spring	130	183	1060	45	947
2005	Greene	6.5	Fall	150	197	3240	3860	5240
			Spring	150	200	3570	4000	4830
2005	Boone	9.0	Fall	130	197	1080	1770	2170
			Spring	130	196	131	2500	1920
2005	Greene	6.5	Fall	120	179	3890	2100	2590
			Spring	120	181	3530	3000	2410
2005	Greene	6.5	Fall	120	152	755	1220	543
			Spring	120	151	712	588	937
2005	Calhoun	7.9	Fall	140	216			
			Spring	140	217			
2005	Greene	6.5	Fall	150	187	2191	3130	3470
			Spring	150	186	2170	3290	2430
2005	Greene	6.5	Fall	150	180	1730	2670	2510
			Spring	150	179	2350	3650	2700
2005	Boone	9.0	Fall	140	234	1160	177	254
			Spring	140	235	779	890	375
2005	Boone	9.0	Fall	140	224	6460	2000	1630
			Spring	140	223	8080	4210	2720
2005	Greene	6.5	Fall	160	201	378	1300	1600
			Spring	160	200	1020	701	1260
2005	Greene	6.5	Fall	160	206	3630	5240	4430
			Spring	160	205	3640	5190	2110
2005	Greene	6.5	Fall	145	207			
			Spring	145	208			
2005	Webster	7.5	Fall	140	189	4730	3090	2250
			Spring	140	193	4470	2970	4340
2005	Adams	10.6	Fall	140	206	307	90	115
			Spring	140	211	2260	2430	907
2005	Greene	6.5	Fall	150	202	2480	740	756
			Spring	150	203	1280	280	324
2005	Greene	6.5	Fall	145	198	3250	4490	7010
			Spring	145	193	4160	3890	4430
2005	Greene	6.5	Fall	140	165	499	359	633
			Spring	140	168	1030	385	738
2005	Greene	6.5	Fall	140	205			
			Spring	140	204			
2005	Greene	6.5	Fall	145	193	3300	1130	3240
			Spring	145	194	3910	2320	3540
2005	Greene	6.5	Fall	145	180	4780	4500	6200
			Spring	145	179	2590	6900	4860
2005	Cerro Gordo	12.5	Fall	110	197			
			Spring	110	197			
2005	Buchanan	6.8	Fall	125	207			
			Spring	125	206			
2005	Buchanan	6.8	Fall	125	179			
			Spring	125	178			
2005	Buchanan	6.8	Fall	125	213			
			Spring	125	212			
2005	Buchanan	6.8	Fall	125	210			
			Spring	125	209			
2005	Buchanan	6.8	Fall	135	204			
			Spring	135	203			
2005	Keokuk	6.2	Fall	160	206			
			Spring	160	204			
2005	Greene	6.5	Fall	140	154	944	1020	796
			Spring	140	159	1580	1080	1880
2005	Greene	6.5	Fall	140	161	2780	940	642
			Spring	140	161	3400	2870	1240
2005	Greene	6.5	Fall	145	195	4810	2350	3730
			Spring	145	196	3820	1990	3940
2005	Story	9.0	Fall	135	188			
			Spring	135	190			
2005	Story	9.0	Fall	135	207			
			Spring	135	206			

Are fall anhydrous losses less than 50 lbs N/acre?

Background

The spring N +/- 50 lb N/acre study has shown it is profitable to reduce N rates by 50 lb in certain categories, especially if using anhydrous ammonia (NH_3). The effectiveness of this management practice can be evaluated by using two-treatment precision farming trials to compare the spring-applied N rate used in the fall vs. spring-applied trial to 50 lb N/acre less in the spring.

What was done

For these trials, producers compared a spring-applied N rate to a spring-applied N rate 50 lb N/acre less. The spring-applied N and spring-applied N - 50 lb N/acre were replicated on 20 or more acres, with strips laid out adjacent to fall-applied NH_3 vs. spring N trials. So far, 22 of these trials were completed and correspond to the top 22 trials in the fall-applied NH_3 vs. spring-applied N table. Stalk samples were also taken for some of these trials as they were in the other study.

What was found

The spring-applied N yielded 194 bu/acre with the spring-applied N - 50 lb N/acre yielding 3 bu/acre less. This response would not pay for the additional cost of the 50 lb N/acre. There were sites where it would be profitable to apply the extra N, if they can be identified before fertilization.

This also means if fall-applied losses did occur they were not equivalent to 50 lb N/acre this year.

The stalk nitrates showed responses could be expected to the reduction in N. The yield data indicated that this did not occur this year.

Conclusions

Fall-applied N losses were less than 50 lb N/acre.

These types of trials need to be conducted for several more years to account for variability in growing seasons.

Summary of Stalk Nitrates

Source	Stalk Nitrate	Stalk Nitrate Categories Low/Marginal	Optimal	Excess
	ppm NO_3-N	-------------------- %	--------------------	
Spring N	2043	17	47	36
Spring N - 50 lb N	696	64	28	8

Summary of Spring vs Spring - 50 lb of N trials

Year	County	March - May Rainfall	Timing	Rate	Grain Yield	Stalk Nitrate		
		----- in -----		-lb/acre -	- bu/acre -	--- ppm nitrate N ---		
2005	Humboldt	8.8	Spring	125	199			
			Spring	75	194			
2005	Humboldt	8.8	Spring	125	188			
			Spring	75	182			
2005	Greene	6.5	Spring	150	189			
			Spring	100	189			
2005	Boone	9.0	Spring	130	187	20	833	1040
			Spring	80	179	20	66	20
2005	Greene	6.5	Spring	150	201			
			Spring	100	200			
2005	Boone	9.0	Spring	130	200	297	1900	1900
			Spring	80	197	20	530	583
2005	Greene	6.5	Spring	120	175	1120	2650	1850
			Spring	70	163	20	29	51
2005	Greene	6.5	Spring	120	148	2030	1120	2270
			Spring	70	151	765	521	1040
2005	Calhoun	7.9	Spring	140	214			
			Spring	90	211			
2005	Greene	6.5	Spring	150	186	1720	3120	2980
			Spring	100	183	1040	1130	1870
2005	Greene	6.5	Spring	150	183			
			Spring	100	177			
2005	Boone	9.0	Spring	140	233	1320	1130	666
			Spring	90	230	329	326	27
2005	Boone	9.0	Spring	140	215	3200	5530	1650
			Spring	90	213	188	750	159
2005	Greene	6.5	Spring	160	198	759	852	1060
			Spring	110	198	715	288	251
2005	Greene	6.5	Spring	160	204	4120	3090	2720
			Spring	110	203	3150	1580	1890
2005	Greene	6.5	Spring	145	203			
			Spring	95	196			
2005	Webster	7.5	Spring	140	185			
			Spring	90	186			
2005	Adams	10.6	Spring	140	210	1140	1720	803
			Spring	100	206	20	302	32
2005	Greene	6.5	Spring	150	189			
			Spring	100	191			
2005	Greene	6.5	Spring	145	195	4130	7320	6140
			Spring	95	190	2950	2450	1730
2005	Greene	6.5	Spring	140	163	651	343	360
			Spring	90	161	28	70	128
2005	Greene	6.5	Spring	140	197			
			Spring	90	196			

N-sufficiency levels in cornfields with injected liquid swine manure

1. Measuring yield responses to extra N

Problem addressed

Large amounts of liquid swine manure are applied to cornfields in Iowa each year. Much of this N is injected below the soil surface to control odors and minimize losses of nutrients.

There is public concern that producers who use this method are applying too much N and may be polluting Iowa's water supplies. Many producers are now required to file and follow nutrient management plans to protect the environment.

The management practices used by these producers should be objectively evaluated by new methods that enable assessments of N-sufficiency levels in cornfields after the manure is applied.

What was done

Corn producers used precision farming technologies in 77 on-farm trials to assess the N-sufficiency levels of corn on fields fertilized with liquid swine manure. The manure was injected into soil with either knives or disk-covers at a constant rate uniformly across fields. Extra fertilizer N was applied in replicated strips across 20 acres or more. Yields were measured by combines equipped with yield monitors and GPS.

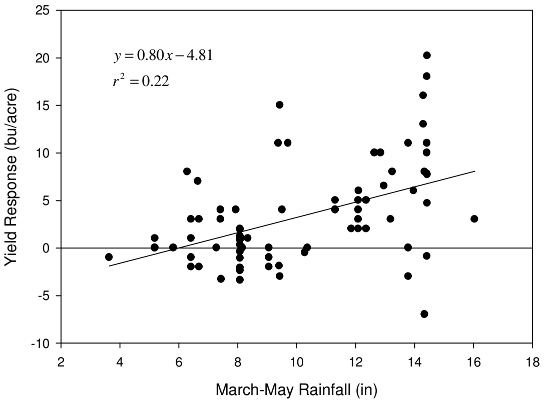
What was found

The mean response to the fertilizer was only 3 bu/acre, which is not enough to purchase and apply the extra fertilizer.

Yield responses were large enough to make additional fertilization profitable at 17 of the 77 sites. However, these profits cannot be attained unless the responsive sites are identified early enough to apply the fertilizer.

There was no significant relationship between the rate of manure-N and yield responses to the fertilizer N.

Yield responses did show a relationship with March through May rainfall. *The amount of N lost during early season rainfall was more important than the base amounts of manure-N applied in these tests.*



Summary of Injected Manure +/- Fertilizer N by year

Year	Number of sites	March - May Rainfall	Manure N Rate[1]	Yield Manure	Yield Response
		----- in -----	lb N/acre	---- bu/acre	----
2004	12	14.1	156	200	8
2001	17	12.4	163	157	5
2002	16	8.3	168	189	3
2000	11	6.6	195	154	2
2005	15	9.5	187	199	2
2003	6	9.9	166	196	0

Conclusions

Application of fertilizer N after the manure decreased profits for most producers. *Programs that help producers recognize this point should be considered an effective way to help them increase profits while reducing losses of N from their fields.*

The observed frequency of yield responses to extra N was much lower than in studies where manure was not injected into the soil. ***This method of manure application performs much better than other methods!***

Because relatively few yield responses were observed, evaluations of these management practices should include use of the end-of-season test for cornstalk nitrate and the late-spring test for soil nitrate. These tests have the ability to assess N-sufficiency levels in the above-optimal range.

Summary of Injected Manure +/- Fertilizer N

County	March - May Rainfall	Manure N Rate[1]	Fertilizer N Rate	Yield Manure	Yield Manure+FN
	----- in -----	---- lb N/acre	----	------- bu/acre	-------
Hancock (05)	14.4	195	75	198	219
Greene (04)	14.4	150	50	192	210
Hardin (04)	14.3	200	50	213	229
Buchanan (02)	9.4	70	65	199	214
Hardin (04)	14.3	160	50	213	226
Hancock (01)	13.8	136	50	154	165
Fayette (01)	9.4	180	50	170	181
Butler (01)	9.7	114	100	105	116
Greene (04)	14.4	150	50	191	202
Kossuth (01)	12.7	207	50	168	178
Washington (04)	12.9	-	50	167	177
Greene (04)	14.4	147	50	202	212
Franklin (01)	13.3	200	80	157	165
Kossuth (02)	6.3	200	50	170	178
Boone (04)	14.4	150	50	198	206
Greene (04)	14.4	147	50	206	214
Hancock (05)	14.4	195	75	186	194
Kossuth (00)	6.7	150	100	159	166
Blackhawk (04)	13.0	-	45	195	202
Greene (03)	12.1	239	60	223	229
Sac (04)	14.0	-	50	214	220
Howard (01)	12.1	166	50	155	160
Boone (01)	12.4	151	50	165	170
Greene (02)	11.3	195	50	178	183
Hancock (05)	14.4	195	75	216	221
Floyd (00)	8.0	85	100	159	163
Hancock (00)	7.4	190	100	147	151
Winnesheik (01)	9.5	200	50	109	113
Howard (01)	12.1	255	45	155	159
Greene (02)	11.3	206	50	176	180
Greene (02)	11.3	187	50	186	190
Hancock (00)	7.4	190	100	159	162
Washington (01)	16.1	-	50	209	212
Howard (01)	12.1	-	60	120	123
Cerro Gordo (02)	6.4	194	50	190	193
Howard (02)	6.7	124	50	187	190
Washington (02)	13.2	-	80	218	221
Floyd (01)	11.9	105	50	170	172
Boone (01)	12.4	151	50	161	163
Howard (01)	12.1	175	45	168	170
Floyd (02)	8.1	110	50	217	219
Hamilton (05)	8.1	115	50	209	211
Hamilton (05)	8.1	-	50	196	197
Chickasaw (00)	8.4	125	100	148	149
Franklin (00)	8.1	250	100	159	160
Cherokee (00)	5.2	152	100	140	141
Cerro Gordo (02)	6.4	194	50	161	162
Hamilton (05)	8.1	285	35	202	202
Hamilton (05)	8.1	136	50	204	205
Hamilton (05)	8.1	130	50	201	202
Buchanan (00)	7.3	300	50	149	149
Cherokee (00)	5.2	236	100	138	138
Cherokee (00)	5.2	299	60	151	151
Hancock (01)	13.8	136	50	172	172
Hancock (01)	13.8	136	50	164	164
Hancock (02)	5.8	190	100	161	161
Fayette (02)	8.2	150	51	182	182
Cerro Gordo (03)	9.1	155	50	184	184
Boone (03)	10.4	150	50	187	187
Hamilton (05)	8.1	285	35	184	184
Hardin (05)	10.3	122	50	175	175
Greene (04)	14.4	147	50	204	203
Greene (00)	3.7	170	120	180	179
Cerro Gordo (02)	6.4	155	50	192	191
Cerro Gordo (03)	9.1	155	50	192	191
Hamilton (05)	8.1	115	50	197	195
Hardin (03)	9.4	140	50	196	195
Cerro Gordo (02)	6.4	194	50	176	174
Howard (02)	6.7	-	50	193	191
Cerro Gordo (03)	9.1	155	50	193	191
Hamilton (05)	8.1	255	50	205	203
Hamilton (05)	8.1	149	50	190	188
Hancock (01)	13.8	136	50	170	167
Buchanan (02)	9.4	180	50	235	232
Webster (05)	7.5	220	50	200	197
Hamilton (05)	8.1	223	50	215	212
Boone (04)	14.4	150	50	201	194
Mean	**10.2**	**173**	**59**	**181**	**184**

[1] Rate calculated from results of manure analysis.

N-sufficiency levels in cornfields with injected liquid swine manure

2. Testing cornstalks for nitrate

Problem addressed

The end-of-season test for cornstalk nitrate is a relatively new tool for assessing N-sufficiency levels in cornfields. This test is being used to survey N-management practices across many fields where reliability cannot be checked. There is a need to demonstrate how the reliability of the test can be checked in precision farming trials and how the test adds information when used in precision farming trials.

What was done

The test was used in on-farm trials where precision farming technologies were used to assess N-sufficiency levels in many (51 over 5 years) cornfields fertilized with injected liquid swine manure as normally applied by producers. Extra fertilizer N was applied in strips after the manure and yield responses were measured.

At five different "pairs of test areas" in the field, cornstalk samples were collected from adjacent strips with and without the extra fertilizer N. The test areas were selected to represent the *range of soil conditions* in the field, rather than the "average" conditions. Individual test results were averaged to represent the field.

Theory

The test essentially asks the plants if they had too little, too much, or just about the right amount of N.

It was "calibrated" in the past by establishing relationships between stalk nitrate concentrations and yield *responses* to added N. Observations made in the past, therefore, are used to assess N-sufficiency level in any field by merely collecting and analyzing samples of cornstalks.

The reliability of the test can be checked by seeing if it correctly identifies sites where the extra fertilizer increased yields ***enough to pay for the fertilizer.***

What was found

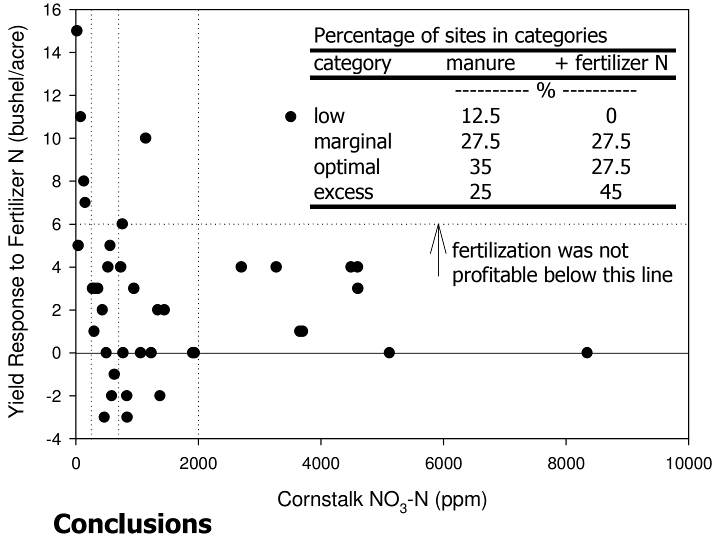
The test correctly identified most fields where application of more N was profitable.

The test seldom indicated deficiencies of N where fertilization was not profitable.

The test showed the effect of the extra N in essentially all fields.

A remarkably high percentage of the fields tested in "marginal-through-optimal" range!

A surprisingly few fields tested in the "excess" range where the fertilizer N was not applied.



Percentage of sites in categories

category	manure	+ fertilizer N
	---------- % ----------	
● low	12.5	0
marginal	27.5	27.5
optimal	35	27.5
excess	25	45

Conclusions

The stalk test used gave essentially the same information as the response trials.

The crop producers did a *much better job* of managing the N in liquid swine manure than the public has been led to believe!

For a post season assessment

For an initial review of what happened last season, an interpretation of the stalk values is needed for each sampling point. Following are the four categories for interpretation, as defined in ISU Pm-1584:

Class	Nitrate Concentration (ppm Nitrate-N)	Interpretation
Low	<250	High probability that greater availability of N would have increased yields
Marginal	250-700	Slightly lower than economic thresholds
Optimal	700-2000	High probability that N availability was within the range to maximize profits
Excess	>2000	High probability that N availability was greater than N applied at economic optimal rates (More N was available than needed for optimal profit)

N-sufficiency levels in cornfields with injected liquid swine manure

3. Testing soils for nitrate in late spring

Problem addressed

The late-spring test of soil nitrate is a relatively new tool for assessing N-sufficiency levels in cornfields. Unlike most soil nitrate tests, this test is intended to be taken *after* manure or fertilizers are applied. N-sufficiency levels are checked just before plants begin rapid growth to evaluate and improve N management practices.

The performance of this test in fields where bands of liquid swine manure were applied has not been clearly evaluated.

What was done

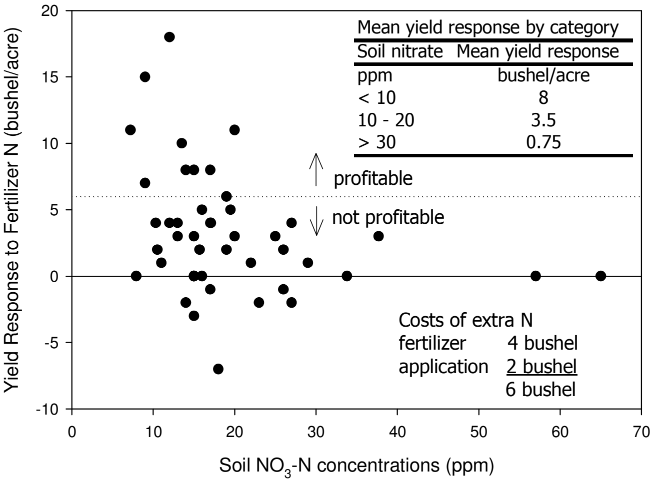
The soil test was used in on-farm trials where precision farming technologies were used to assess N-sufficiency levels in many (45 over 5 years) cornfields fertilized with injected liquid swine manure as normally applied by producers. Fertilizer N was applied in strips after the manure and yield responses were measured.

Soil samples were collected to represent the surface foot of soil at five "test areas" (without the fertilizer N) in each field when plants were about 6 inches tall. Each sample was a composite of 24 cores collected at various distances between rows to avoid taking too many cores within or between the bands of manure. Separate tests for the areas were averaged to represent the field.

Theory

The test essentially asks if the concentration of nitrate in the soil is close to the concentration previously found to most likely maximize profits for producers. It was "calibrated" in the past by establishing relationships between soil nitrate concentrations and yield *responses* observed in N-response trials.

The reliability of the test can be evaluated by seeing if it correctly identifies sites where the extra fertilizer increased yields ***enough to pay for the fertilizer.***



Mean yield response by category

Soil nitrate	Mean yield response
ppm	bushel/acre
< 10	8
10 - 20	3.5
> 30	0.75

Costs of extra N

fertilizer	4 bushel
application	2 bushel
	6 bushel

The recommended critical concentration for injected liquid swine manure is 10 ppm.

For more information about these critical concentrations, go to
A. M. Blackmer, N.C. Yang, and D.J. Hansen. 1999. What does the late-spring soil test really measure? In proceedings of the 11th Annual Crop Management Conference, Iowa State University, Ames.

and

A. M. Blackmer. 1998. Hold nitrogen on manured cornfields in 2000. Integrated Crop Management (available online http://www.ipm.iastate.edu/ipm/icm/2000/2-28-2000/holdnit.html)

What was found

The soil test usually was not needed in fields with injected liquid swine manure because the manure usually supplied adequate N for plant growth and relatively few fields had great excesses of N.

Fertilization was profitable at 9 out of 45 sites and fertilizer increased yields by an average of only 5.7% at these sites. *Any cost of soil testing would be difficult to justify under these conditions.*

The test did reasonably well if the critical concentrations for the test were those specifically recommended for injected liquid swine manure (i.e., 10 ppm).

Surprisingly, the soil test results indicate that N management may be less of a problem on fields receiving liquid swine manure than on most other cornfields in Iowa.

Conclusions

There is little reason to use the late-spring test for soil nitrate on fields with injected liquid swine manure *unless* a problem is suspected.

If the soil test is used on these fields, the appropriate critical concentration for nitrate should be used.

The most practical tools for evaluating and improving N management in such fields are the end-of-season test for cornstalk nitrate and measuring yield responses to extra N in precision farming trials.

Some *surprising and important* outcomes can be expected from programs that objectively evaluate the performance of N management practices. Iowa's economy and environment will benefit.

Use of cumulative distribution functions of yield responses to estimate optimal N rates on the scale of farm

Problem addressed

The small number of yield response observations collected in the past limited development of reliable methods for calculate N optimal rates for corn. Modern precision farming technologies give producers the ability to quickly and easily collect a number of yield responses to N on a large scale.

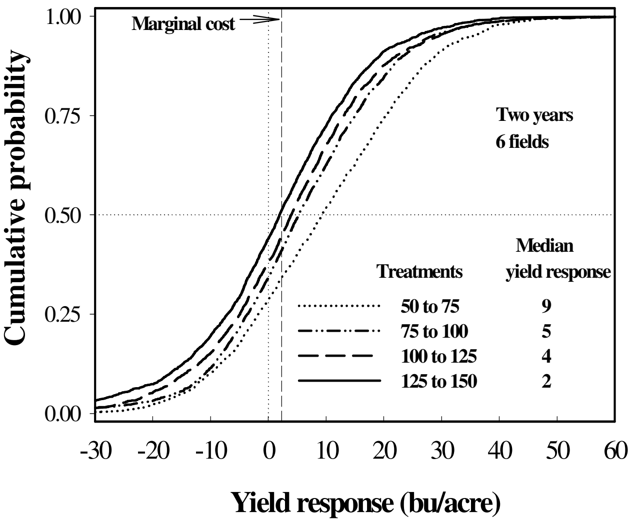
Recent findings that discrete marginal products (DMPs) of N fertilization are nearly linear related to N rates in the near-optimal range could be potentially used to calculate optimal N rates from two-treatment N response trials. However, reducing errors of estimating mean yields in the near-optimal range and controlling unexplained variability in yield response become of significant importance.

This study explored the opportunity for reducing these errors by collecting appropriate sample of yield response over a large area of soils and calculating N optimal rates using cumulative distribution functions (CDFs).

What was done

Nitrogen fertilizer treatments in a form of urea ammonium nitrate solution were applied to corn after soybean in 6-row strips at five rates of 0, 50, 75, 125 and 150 lb N/acre, covering six entire 80-acre fields on the same farm over a two year period. The fields were under a no-till till system. The fertilizer strips were applied after corn plants had emerged.

The producer harvested corn strips with a combine equipped with yield monitor and GPS. Yield responses were calculated for each fertilizer increment by setting up 40-foot grid cells using GIS. Cumulative distribution functions (CDFs) of yield responses were generated for each N fertilizer increment. CDF plots show a probability that a given yield response takes a value less or equal to the magnitude of a given yield response from additional N.



Fertilizer N price was \$0.20/lb and corn grain price was \$2.20/bu. The marginal cost was calculated as 2.3 bu for a 25 lb N/acre fertilizer increment.

Characteristics of CDFs

Medians of CDFs are middle points of yield response distributions: 50% of yield response observations are below and 50% of the observations are above the media value. Unlike means, median yield responses are not affected by extreme low and high yield responses. Therefore, CDFs are effective in controlling errors in yield measurements when corn strips are harvested over the large areas of spatially variable soils.

What was found

Medians of CDFs show diminishing yield responses from successive fertilizer increments. Fertilizer N was profitable to apply when CDFs crossed the 50% line (horizontal line) on the right side of the marginal cost line. Fertilizer N was not profitable to apply when CDFs crossed the 50% line on the left side of the marginal cost line. Applying fertilizer was highly profitable up to 125 lb N/acre rate for the sample of yield response of six fields over two years. An optimal N rate for maximizing profit for this farm was between 125 and 150 lb N/acre.

A precise estimate of N optimal rate can be calculated by plugging in a median yield response of two N rates (100 and 150 lb N/cre) in the near-optimal range in the N calculator. An optimal N rate was estimated as 145 lb N/acre and an optimal rate with the desired rate of profit (25%) was estimated as 126 lb N/acre.

Advantages of using CDFs of yield responses

1) All variability in yield responses is shown. This variability is important when considering the possibility of subdividing distributions of yield responses into crop categories with different N optimal rates.
2) Effects of errors in yield measurements on optimal N rates are minimized.
3) No need to use traditional statistics for the analysis of yield responses.

Conclusions

CDFs of yield responses collected in the near-optimal range of N fertilization provide a simple and effective way to address variability in yield response and estimate N optimal rates.

Collecting a large number of yield response observations on a farm scale is an essential step in the overall procedure for determining the N fertilizer needed for corn.

A multi-step procedure for estimating optimal rates of N fertilization in on-farm N response trials

Step 1. Define the area of interest (a field, a farm, a group of farms, a county) that will adequately represent the range of conditions for which the optimal rates of N fertilization will be estimated for the corn crop in on-farm trials. Collect a sample of yield responses that is reasonably distributed within the area of interest both in space (across soil types, hybrids, tillage systems, management practices) and in time (across years) using precision farming technologies.

Step 2. Apply two rates of N fertilization in the near-optimal range. The major assumption is that information collected within the optimal range is more reliable than information collected outside the optimal range. Restricting N treatments to the narrow window will reduce undue effects of N rates applied below and above the optimal range on estimates of optimal N rates. *Crop producers usually have approximate estimates of the optimal N range for their soils, fields, and management practices.*

Select fertilization practices (time, method of application, and N fertilizer forms) that do not lead to losses of N by leaching or denitrification.

Step 3. Collect yield data using precision farming technologies. Calculate yield responses to applied N based on strip means and generate distributions of yield responses based on means of individual grid cells. Yield responses calculated based on strip means will be used to calculate one optimal rate that will likely maximize profit per acre for the whole area of interest. Distributions of yield responses of individual grid cells will be used for further analysis for calculating two or more N optimal rates for the area of interest.

Step 4. Use cumulative distribution functions of yield responses of individual grid cells to calculate median yield responses and get an approximate estimate of optimal N rate. Median yield responses are not affected by errors and extreme values.

Step 5. Use discrete marginal analysis method for calculating one optimal rate that *maximized profit per acre* for the whole area and one optimal N rate *that gave the desired rate of profit on the last pound or the last increment of N applied*. These optimal rates are calculated in after-the-fact analysis (under certainty) and they are called *ex post* optimal N rates. *Ex post* optimal N rates are used to estimate optimal N rates for the future, recommendations or *ex ante* optimal N rates (under uncertainty). *Ex post* optimal N rates estimated in this step must contain as few errors as possible.

In this step, greater emphasis is placed on distinguishing between rates that just pay the direct cost associated with the last increment of N applied and rates that give a desired level of profit on the last increment of N applied. Variability in yield response is ignored in this step.

Step 6. Classify distributions of yield responses into predictable crop categories and calculate N fertilizer needs for each category. Each new category will have its own optimal N rate. Variability in yield response is considered in this step. The purpose of classification is to reduce variability in yield response by forming categories with different N fertilizer needs. The benefit of classifying should be larger than the cost. The benefit will come from maximizing profits by *differentiating areas where more N is needed from areas where less N is needed.*

For classification, consider factors that are known before applying fertilizer (anteceding weather, previous crop, soil spatial properties, hybrid, method of application, tillage etc.). Make sure a good sample of yield responses is included in each sample of a newly formed crop category.

Step 7. Repeat steps 4 and 5 for each newly formed category. The overall procedure requires collecting yield response observations on large scales. This can be accomplished by applying two N rates in the near-optimal range in on-farm trials by group of producers interesting in improving N management practices.

Equivalency of N supplied in liquid swine manure - 2005

Background information

Liquid swine manure is commonly used as a source of N for corn. N supplied in manure is in both organic and inorganic forms. While inorganic N is immediately available to plants, organic forms of N should go through microbial transformation before this N can be taken up by plants. In addition, manure contains carbon in forms of grain, undigested feed, corn stalks etc., and soil microorganisms consume inorganic N while using this carbon in manure as a food during the process called immobilization. Thus, it is difficult to estimate when and in what quantity N applied in manure will be available for the corn crop.

The objective of this study was to calculate equivalency (credits) of N supplied in liquid swine manure as compared to N supplied as commercial fertilizer.

What was done

Liquid swine manure was injected into the soil at three sites in the West Buttrick Creek Watershed in mid April. Manure was applied at a rate of 150 lb of total N/acre at two sites and 125 lb of total N/acre at one site. Two sites were planted to corn after soybean and one site was planted to corn after corn.

Urea ammonium nitrate (UAN) solution was sidedressed at rates of 50, 100,150, and 200 lb N/acre on June 2 at each site.

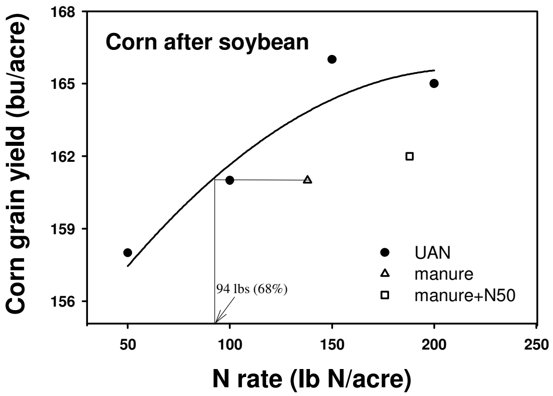
Manure and UAN treatments were applied in 300-foot long strips in four replications. The corn strips were harvested with a combine equipped with a yield monitor and GPS receiver.

What was found

- Corn after soybean

High variability in yields was observed for both UAN and manure treatments. When data from two sites for corn after soybean were pooled, N applied in manure was equivalent to 68 % of N applied as UAN.

Addition of 50 lb N/acre in UAN on top of manure increased yields but yields did not reach a maximum.



It is necessary to note, however, that **yield responses observed in this study were probably too small to be detected as statistically different in traditional small-plot experiments**.

UAN and manure treatments	Stalk nitrate
--------lb N/acre--------	---------ppm---------
N50	520
N100	1360
N150	3050
N200	3610
Manure (N138)†	1840
Manure (N138)+N50	3390

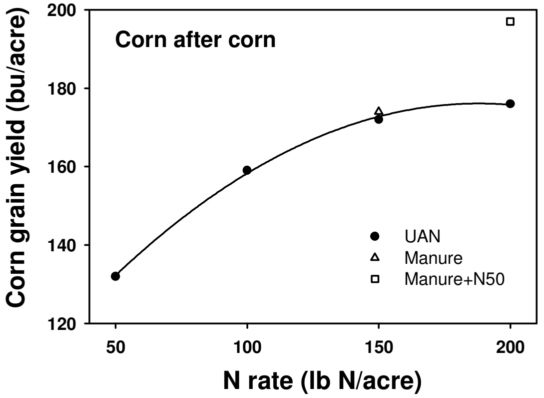
†Total organic N based on manure analysis.

Corn stalk nitrate data showed less variability among treatments than yield data. The data confirmed that 100 lb N/acre applied as UAN was sufficient to maximize profit.

- Corn after corn

Corn responded to N applied as UAN until 150 lb N/acre. Treatments with N applied in manure yielded higher than N treatments applied as UAN. Thus, it was impossible to calculate percentage equivalency of N applied in manure for this site.

It is difficult to explain why yields tended to be higher with manure treatments. One possible explanation could be that UAN was injected into the soil layer at 2-3 in. deep, where the most corn residues remained from the last year. As a result, more N from the fertilizer could have been tied up by carbon than N from manure.



UAN and manure treatments	Stalk nitrate
-------lb N/acre---------	---------ppm---------
N50	90
N100	150
N150	940
N200	3180
Manure (N150)†	640
Manure (N150)+N50	1850

†Total organic N based on manure analysis.

Corn stalk nitrate data at this site showed less variability than yield data. The data confirmed that 150 lb N/acre was sufficient to maximize profit. Stalk nitrate data did not support yield observations that manure supplied more N than UAN.

Conclusion

At two sites for corn after soybean, N supplied in liquid swine manure was only 68% equivalent to N supplied as UAN. At one site for corn after corn, unexplained variability in yields did not allow an estimate of equivalency of N.

On-farm manure studies provide valuable information for condition-specific for different soils, type of manures, and management practices.

Interpreting the results from “guided” stalk nitrate samples

Interpreting the results

Receiving the stalk nitrate results is only part of the information needed to fully understand what happened in the previous season and determine how to use it to guide future management.

Many factors influence the N status of a corn plant such as overall plant health and the amount of available N in the soil. Factors such as rainfall, growing conditions, and amount of N from both fertilizer and other sources (such as organic matter) must all be considered while trying to understand what happened last season.

Some factors, such as applied fertilizer N or a tillage practice, are uniform across the field. Other factors, such as soil types, vary considerably within a field. Individual sample values may accurately represent only the areas where they are collected because of the variability.

For a post season assessment

For an initial review of what happened last season, an interpretation of the stalk values is needed for each sampling point. Following are the four categories for interpretation, as defined in ISU Pm-1584:

Class	Nitrate Concentration (ppm Nitrate-N)	Interpretation
Low	<250	High probability that greater availability of N would have increased yields
Marginal	250-700	Slightly lower than economic thresholds and with improved lab testing procedures, **this class is combined with the optimal class**
Optimal	700-2000	High probability that N availability was within the range to maximize profits
Excess	>2000	High probability that N availability was greater than N applied at economic optimal rates (More N was available than needed for optimal profit)

Selecting multiple samples in a variable field

Because most fields contain so much spatial variability and because of the dynamic nature of N availability, multiple samples should be collected from each field. The default protocol in the program is to collect four different samples from pre-selected sampling points. Three of the samples are selected to represent three major soil map units (SMU) in the field. The fourth point is selected based upon areas that appear deficient in the aerial image.

Translating multiple samples into a field interpretation

Because fields are variable, it is common for samples to vary in their interpretation class within the same field. Most fields are still managed with a constant rate of N application and require a field level interpretation.

Samples taken from points that are selected based on deficiencies identified with the aerial image should be treated differently than samples collected based on a soil map unit. The sample from the deficient area is the most biased sample because we are looking for a stressed area as opposed to a representative point. If only the sample collected from the deficient area is classified low and the area appearing deficient is relatively small, the field should not be considered deficient for N.

The three SMU samples do represent a range of conditions in the field. Many factors beyond SMU affect N status within a field so don’t assume a single point accurately represents all of a given SMU. Instead, think of the three points as three different assessments and make a judgment based upon the three. Because of the economic penalty of yield loss, one of the three SMU samples testing low can be basis for classifying the field as low – especially if there is a “deficient” point sampled that is also low.

Below is a suggested table for field level interpretations

Field Level determination	Defining criteria
Low	1 or more of the SMU samples testing low or the “deficient” sample representing <u>large</u> areas of stress from imagery is low
Optimal	2 or more of SMU samples in “optimal” range and no “low” testing samples
Excess	2 or more of SMU samples in “excess” range

Interpreting the results from “guided” stalk nitrate samples

Interpreting field results with consideration to rainfall

The N status of a field is affected by many factors – especially spring rainfall. MULTIPLE YEARS OF EVALUATION IS STRONGLY RECOMMENDED TO CAPTURE A RANGE OF CONDITIONS. Below is a chart to illustrate a basic interpretation of the field determination with consideration to weather. Prior research in Iowa has shown that the cumulative rainfall from March through May has significant impact upon both crop N status and nitrates in the river water.

Minimizing losses can increase N availability

Nitrogen availability can be increased in a number of different ways. The obvious option is to increase the rate of applied N to the soil. Many times, the option of reducing the loss of applied N is the more economic alternative. Comparisons of rates used in a given system/region and their outcomes should be examined to determine if N loss is a significant problem. Factors such as fertilization timing, form and placement can have significant impacts on N loss.

Scenario	Description of samples	Field N determination	Weather/loss (spring rainfall)	Future recommendation*
#1	1 or more of the SMU samples testing low or “deficient” sample representing large area of stress from imagery	Low	Above Average	Stay the same/Watch for need to increase N availability
			Average	Change to increase N availability
			Below Average	Change to increase N availability
#2	2 or more of SMU samples in “optimal” range and no “low” testing samples	Optimal	Above Average	Stay the same/Consider reduction
			Average	Stay the same
			Below Average	Stay the same/Watch for need to increase N availability
#3	2 or more of SMU samples in “excess” range	Excess	Above Average	Decrease added N
			Average	Decrease added N
			Below Average	Stay the same/Watch for need to decrease N

*The future recommendation is only to give general guidance. Measuring yield responses with strip testing to quantify actual amounts of N are recommended.

Ammonia volatilization from surface-applied urea fertilizer

Problem addressed

It has long been known that significant amounts of fertilizer N can be lost from fields by “ammonia volatilization” when urea is applied to soil surfaces and not incorporated.

Most corn producers do not understand the processes involved or when large losses of N are most likely to occur.

Chemical forms of N

Urea is a form of N often used in fertilizers.

- It is the only form of N in “solid” *urea* (46-0-0).
- It supplies about half the N in 28 or 32% N solutions.
- It is very soluble and moves with water in soil.
- N in *urea* is not available to plants until the urea is “hydrolyzed” to *ammonium* by enzymes in soil.

Ammonium is a form of N often used in fertilizers.

- It is a positively charged ion and soluble in water.
- It is strongly attracted to soil particles, so it does not move with water in soils.
- Some *ammonium* always transforms to *ammonia* until a certain equilibrium concentration of this gas is reached.

Ammonia is a form N often used in fertilizers.

- It is a gas and commonly called “anhydrous ammonia”.
- When at the soil surface, it moves with the wind.
- When ammonia is blown away, the resulting decrease in concentration near the soil causes more *ammonium* to transform to *ammonia*. Like water “evaporates”, *ammonia* “volatilizes”.

Effects of soil pH

Soil pH has a profound effect on the concentration of ammonia in equilibrium with ammonium. *High pH promotes volatilization of ammonia just as high temperature promotes evaporation of water.*

- At a pH of 5.0, the equilibrium concentration of ammonia is so low that little N can be lost to the wind.
- At a pH of 7.5, the equilibrium concentration of ammonia is high enough that most of the N can be lost to the wind in a few days.

Unique problems with urea

When urea is “hydrolyzed” to ammonium, an associated chemical reaction increases soil pH.

- This increase in pH occurs exactly when and where the ammonium is released into the soil
- The localized increase in pH promotes losses by ammonia volatilization in soils, even in soils where ammonia would not normally form.
- Plant residues have enzymes that promote rapid hydrolysis of urea and, therefore, tend to promote ammonia volatilization from urea.

N losses often are negligible

Many factors can make losses of N by ammonia volatilization insignificant. The major reason is that ammonia is not free to move with the wind when it is an inch or more below the soil surface.

- Incorporating urea into the soil prevents N losses by ammonia volatilization.
- Urea applied to a dry soil surface remains inactive until it rains.
- Because urea moves with soil water, a small rainfall can move the urea into the soil deep enough to prevent losses.

Much of the N *can be* lost

Essentially all the N fertilizer can be lost under some conditions.

- When urea is applied to a wet soil surface, the urea is hydrolyzed at the soil surface and ammonia formed is free to move with the wind.
- When the urea is applied as a prill or a granule, soil pH increases substantially where the ammonium is formed.

Application of urea to soil surfaces without incorporation should be considered a high-risk method of fertilization. Most corn producers would avoid this method of N fertilization if they knew how frequently significant losses occur and yields are reduced by deficiencies of N.

Losses of N from fertilizer solutions sprayed on soils

Problem addressed

Fertilizer solutions containing 28 to 32% nitrogen (N) are often sprayed on the surface of cornfields and not incorporated into the soil. This is commonly done in "weed and feed" programs.

Mounting evidence suggests that substantial amounts of this N is often lost before plants grow, but the amount lost varies greatly among sites and years.

It should be noted that incorporating the fertilizer into the soil greatly reduces the problems discussed here. Dribbling the solution as a band significantly reduces the problem.

Forms of N

About half of the N in the fertilizer solution is present as *urea*. This form of N is very soluble in water and not attracted to soil particles, so it is free to move with water in soils. When soils are warm and moist, enzymes in soil convert *urea* to *ammonium* within a day or two.

About one quarter of the N in the solution is *ammonium*. This form of N is positively charged and strongly attracted to soil particles, so it usually does not move with water in soils. When soils are warm and moist, soil microorganisms "nitrify" this N to *nitrate* within a week.

About one quarter of the N in the solution is *nitrate*. This negatively charged form of N is repelled from soil particles and is free to move with water in soils. This is the form of N usually taken up by plant roots.

What happens to the N?

Many different things *can* happen to the fertilizer N after it is applied to soils. What actually happens depends on many factors. When the fertilizer is applied at planting time (so the soils are relatively warm), what happens is mostly determined by soil water content at the time of application and rainfall after application. **A key issue is how *urea* and *nitrate* move with soil water when it rains.**

When sprayed on a dry soil surface, essentially no losses occur until it rains. Movements and transformations of N are essentially stopped due to lack of water. This situation is likely if aggregates on the soil surface are dry enough to form powder when crushed.

When the first rainfall occurs after fertilizer solutions are sprayed on a dry soil surface, the intensity and amount of rainfall determines what happens to the N.

- If the first rainfall is light-to-moderate in intensity and amount (for example, a half inch over several hours), the urea and nitrate will be carried below the surface but remain in the rooting zone. Essentially no N is lost. **This is the most desirable situation that can occur.**
- If the first rainfall is intense, urea and nitrate at the surface will tend to move with the water. This movement occurs whether the water flows over the soil surface or downward through the soil profile. **Losses are relatively small if** the soil profile is relatively dry and can catch and hold all the water. **Losses are relatively large if** the soil profile is already filled with water, so water must run off the field or move through the soil profile. Soils that drain the most rapidly are likely to lose the most N. **Nitrate leaching happens!** It can result in large losses of fertilizer N before plants grow.

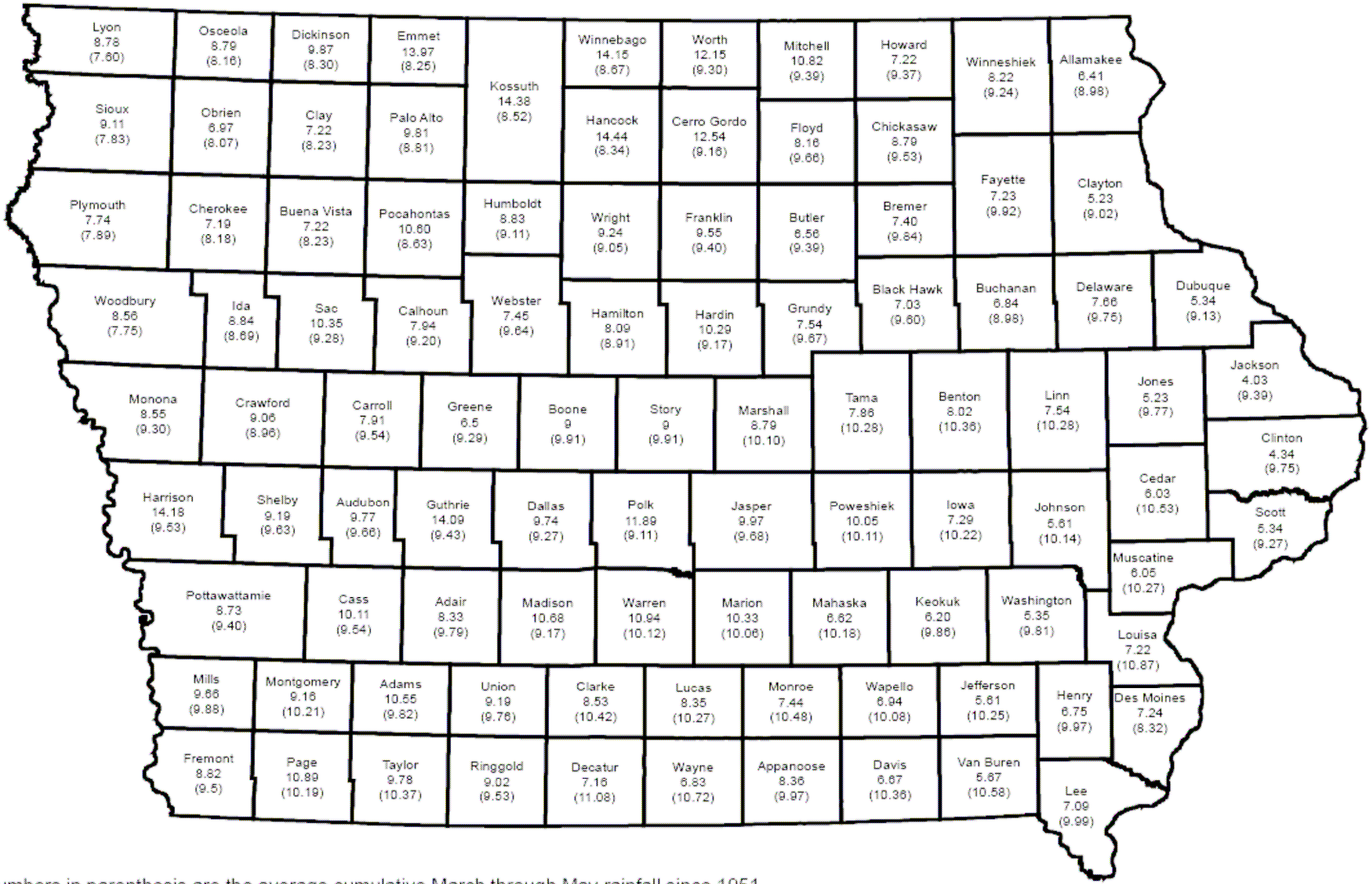
When fertilizer solutions are spayed on wet soil surfaces, losses of N by ammonia volatilization can be substantial. The major reasons are (1) the urea is converted to ammonium at the soil surface, (2) this conversion results in a localized and temporary increase in soil pH, (3) the increase in pH causes the ammonium to transform to ammonia, and (4) ammonia is a gaseous form of N that can be blown away by the wind. High percentages of the N added as urea and ammonium can be lost.

When fertilizer solutions are sprayed on wet soil surfaces and the first rainfall is intense but does not occur for many days, the rainfall can leach away much of the nitrate that has accumulated at the soil surface. **This is probably the worst situation** because substantial losses of N can occur by leaching as well as by ammonia volatilization. No-till soils are likely to have wet surfaces because plant residues are present.

The bottom line

Losses of N can be large or small when fertilizer solutions are sprayed on the soil surface. The amounts of N lost depend on many factors that cannot be predicted in advance. When compared to many alternative methods of N fertilizer application, this method results in a relatively high frequency of cases where yields are significantly reduced by losses of N before plants grow.

2005 Cumulative March through May Rainfall



Numbers in parenthesis are the average cumulative March through May rainfall since 1951.

Data provided by Iowa Environmental Mesonet, Department of Agronomy

Iowa’s two-treatment trials with precision farming technologies

1. A general introduction focusing on N-response trials

Background

Two-treatment response trials are being used to evaluate and improve N management practices in Iowa. The methods being used evolved during a decade of research to learn how precision farming technologies could best be used to identify practices that increase profits for crop producers while reducing environmental problems.

More details follow!

Basic design

- The trials are conducted on fields typical of those normally managed by cooperating crop producers. Except for the treatments being compared, all management practices used are those normally used by the producer.
- The treatments compared usually are the producer’s normal practice and one expected to be superior. A treatment can refer to any specific combination of rate of application, time of application, form of N, or placement of N.
- Two treatments are applied in alternating strips going the lengths of fields and plant responses are measured. The width of each strip is usually at least twice the width of the combine head that will be used. A minimum of five strips for each treatment is preferred.
- Plant responses to treatments usually are assessed by remote sensing and yield monitoring. Means for whole strips are analyzed when spatial variation within fields is ignored, but means for short segments of strips are analyzed when spatial variation within fields is characterized.
- Samples of soil and (or) plant tissue are often collected within selected “test areas” and analyzed to aid in interpretation of the results.
- The same two treatments are compared in trials conducted on many different farms and years. The mean effects of treatments across all sites and years is calculated. Data from all sites are pooled and analyzed to identify site-specific factors that may help explain and predict responses to treatments.

Key expectations

- Treatments focus on a question of interest *to producers.*
- Trials must be easy for producers to rapidly establish with their equipment.
- Results must be easily understood.
- The treatments should not produce long lasting effects that prevent future studies at the same site.
- Many replications within sites are used to minimize the number of situations where responses that are economically important to producers are “statistically insignificant.”
- Treatment strips are relatively narrow (and treatments must be few) to give high spatial resolution when relating responses to soil characteristics.
- Comparisons of treatments must be conducted over many sites and years to identify important interactions of treatments, soil characteristics, and weather.
- Enough data is collected to give reasonable estimates of the risk and benefits associated with selecting one practice over another within the range of conditions studied.

Iowa's two-treatment trials with precision farming technologies

2. The "ultimate" N-response trials

Run response trials across the landscape at no net cost!

The *"ultimate"* trials?

The rationale for the design of Iowa's two-treatment precision farming trials is easier to understand if a longer-range vision is presented. Discussion of the "ultimate" N-response trials should help.

Overall need for the trials

Crop producers need methods that enable rapid collection, analysis, and interpretation of large amounts of site-specific data at the lowest possible cost. The information must be transformed to a form that producers can use to increase their profits.

Specific problems to be solved

- The benefits from selecting one N-fertilization practice (rate, time, placement, or form of N) over others cannot be assessed without knowledge of effects on yields. *Measured yield responses enable calculation of the value of a treatment to producers.*
- Even when important to producers, the yield differences often are too small to measure by traditional methods. *Spatial and temporal variability is a problem that has not been solved!*
- Because the effects on yields vary with many unknown factors, yield differences must be measured under conditions relevant to each producer. Moreover, they should be measured in ways that enable producers to manage spatial and temporal variability within their fields. *This was impossible in the past!*
- The costs of data collection and analysis must be less than the value of the information received. *With these trials, there is no net cost to the producer!*

Key assumptions

- It soon will be practical to fertilize all fields with applicators having GPS guidance systems and variable-rate capacity. *Treatments can be applied in strips across many fields at essentially no cost.*
- Combine swaths can be easily aligned with treatment strips. *Yield response data can be collected at essentially no cost.*
- Producers have considerable knowledge, so they would select only treatments that can refine this knowledge. *Yield differences should be relatively small; the cost of yield losses should be less than the value of the new information acquired.*
- Advances in technologies will enable rapid, simple, and inexpensive analysis of data. *Some analyses may be off-farm, but the costs would be relatively small and the results easy to verify.*

Key outcomes expected

- Mean differences in yield can be calculated for a field or group of fields. *Average economic benefits can be calculated.*
- Yield-difference maps can be calculated for small grids within fields to characterize spatial patterns in response. *Soil factors affecting yield responses can be studied, and practices can be adjusted as needed.*
- Two rates of N (slightly above and below the estimated optimal rate) can be applied in alternating strips across large areas of land. Yield differences can be used to refine estimates of optimal rates and the process can be repeated year after year. *Variable-rate applications of N can be optimized over time.*
- Results from many fields and years can be pooled to study the effects of soil, weather, and management practices. Interactions can be studied. *Groups of producers can do what none can do alone.*

Iowa's two-treatment response trials with precision farming technologies

3. Current methods for establishing N-response trials

Problem addressed

Two-treatment response trials are being used to evaluate and improve N management practices in Iowa. The methods being used evolved during a decade of research to learn how precision farming technologies could best be used to identify practices that maximize profits while minimizing environmental problems.

The methods currently used are based on the assumption that trials can be established with little cost or effort in the future as new technologies are refined. Here are the protocols currently being used to establish the trials.

Selection of fields

- Producers are selected on the basis of experience with yield-monitoring combines and interest in participating.
- Efforts are made to select fields where prominent ridges and valleys go perpendicular (rather than parallel) to rows of corn.
- Fields that have normal or slightly above-normal variability in soil map units are selected over fields that have essentially no variability or extreme variability.
- Studies usually are confined to areas that contain a single hybrid and have uniform management except for the treatments applied.
- Fields often are selected after N deficiencies or other specific problems are noted.

Overview of the methods

- Fields are divided into "strips" for fertilizer treatments and "swaths" that the combine will follow during harvest.
- Treatments are applied starting from the same side of the field as planting.
- To minimize errors, colored flags are placed at the ends of rows to denote treatment strips and (or) combine swaths. The positions of all flags are recorded by GPS.
- Each fertilizer strip usually is two combine swaths wide.
- When the width of the fertilizer applicator does not correspond to two or more combine swaths, combine swaths with two treatments are included in plans but not analyzed.
- Small "test areas" for collection of soil and plant samples are marked by flags. "Matched pairs" of test areas are placed side by side in adjacent strips within an area where plant stands and soils seem relatively uniform.

Methods of aligning treatments and swaths

- When fertilizer treatments are applied after the corn has emerged, combine swaths can be identified before treatments are applied and rows of corn can be followed when applying fertilizer.
- On no-till fields, stubble rows from the previous crop can be used to guide application of fertilizer and planting. Anhydrous ammonia knife tracks (with or without application of N) can be used to mark these fields.
- The lower rate of fertilizer N can be applied uniformly across the entire field before planting. Planter marks and wheel tracks can be used to identify combine swathes and apply treatments.
- Fertilizer treatments can be applied using GPS guidance systems before fields are tilled and planted.

Iowa's two-treatment trials with precision farming technologies

4. Should *non-fertilized* controls be included in N-response trials?

Problem addressed

Small-plot experiments to characterize the response of crops to fertilizer N have always included non-fertilized "control" plots. There is no scientifically valid reason, however, for including such treatments in all response trials.

The costs of including *non-fertilized* controls often far outweigh the benefits in field-scale trials conducted with precision farming technologies. The precision farming trials include "controls", but these receive N at a rate that is only slightly less than optimal based on existing knowledge.

There is need for discussion of when *non-fertilized* controls should be included and when they should be avoided in trials designed to refine current estimates of N fertilizer needs.

When not needed, non-fertilized controls increase costs, decrease sensitivity, and inflate estimates of N fertilizer needs.

Recommendations

Non-fertilized controls should be included *if and only if* application of no fertilizer N is considered to be a reasonable recommendation. Examples: Non-fertilized controls **should be** included where manure was recently applied or where alfalfa was the previous crop; non-fertilized controls **should not be** included for corn after corn or corn after soybean where manure was not recently applied.

When precision farming technologies are used in strip-plot trials, two rates of N should be selected in the near-optimal range. The rates could be 25 lb N/acre above and below the rate expected to be the best recommendation, and the lower rate serves as the control. On-going studies show that the results of two-treatment trials can be analyzed objectively by using generally accepted economic and statistical methods.

Problems caused by non-fertilized controls when not recommended

- **Complexity of the trials is increased**. Fewer producers will participate because trials with many treatments are difficult to establish.
- **Border strips must be added between strips harvested**. Plant roots crossing the border between plots create errors when differences between plots are extreme. Border strips complicate experimental designs.
- **Costs are greatly increased.** Yield losses due to extreme deficiencies of N become prohibitive when trials cover many acres. They may affect yield history and government payments.
- **Producers dislike having strips of "yellow corn" in their fields**. Landlords often consider this a sign of poor management.
- **Value of a field for future studies is reduced.** Residual effects of extreme deficiencies spoil the field for studies in future years.
- **Potential for replication is reduced**. Only a fixed number of strips can be placed in a field, so increasing the number of treatments reduces ability to increase replication. Several replications are needed to detect small responses with acceptable levels of confidence.
- **Model bias injects hidden errors**. When trials include several rates and non-fertilized controls, the results are usually interpreted by fitting models that inject a bias that is often important but ignored.
- **High rates of N fertilization are promoted**. Emphasizing the great responses to the first increments of fertilizer N encourages producers to expect benefits from successive increments. Modern producers need objective assessments of the benefits of successive increases in rates of fertilization.
- **Ability to address spatial variability is diminished.** Adding more treatments and buffers between treatments greatly reduces ability to resolve areas that have different optimal rates of N fertilization. This loss of spatial resolution reduces the precision with which optimal rates can be identified. Trials must be designed to help producers address spatial variability in N fertilizer needs.

Iowa's two-treatment trials with precision farming technologies

5. Defining "optimal" rates of N fertilization

Problem addressed

The word "optimal" is often used when discussing rates of N fertilization, but there is confusion about what is actually denoted when this word is used.

Clear definitions for "optimal" and related terms are needed to understand how Iowa's two-treatment trials with precision farming technologies are being used to identify optimal rates of N fertilization.

The definition should make it clear that any assessment of "optimal" rates of N fertilization must include consideration of profits for producers. The definition must clearly indicate that everyone recognizes that the N rate that maximized profits in a field last year is not necessarily the rate that will maximize profits this year.

Optimal rates of N defined

Because fertilizer N must be applied *before* plants grow, the "optimal" rate of N fertilization should be considered the rate *most likely* to maximize profits for producers.

- This rate can never be exactly measured, it only can be *estimated*.
- This rate should be expected to change slightly with changes in costs of application and prices for fertilizer and grain.
- This rate should be expected to change slightly with advances in knowledge and technologies.
- This rate can vary from year to year with weather and other factors that occur *before* fertilizers are applied.
- This rate does not vary year to year with weather after fertilization or other factors that cannot be predicted or controlled.
- This rate could change with method or time of fertilization, but the costs and benefits of alternatives must be considered.
- In technical terms, this rate can be described as the "*ex ante* economically optimal rate of N fertilization".

Methods for estimating optimal rates

The method used involves measuring yield responses to fertilizer N at many sites representing the distribution of conditions likely to be encountered and then doing after-the-fact calculations to identify which single rate (or recommendation system) would have maximized profits across all these conditions.

- This method assumes only that what happed in the past can be used to predict what will happen in the future.
- Many observations are needed to address the unknown or unpredictable effects of weather and other factors.
- Estimates of optimal rates can be continuously evaluated and improved as more observations are made by producers.
- Estimates of optimal rates can be refined by identifying conditions that should be distinguished and managed differently.
- Estimates of optimal rates can be linked directly to profits for producers. The loss of profit from not using the most profitable rate can be estimated.
- In technical terms, these estimates can be described as "*ex post* economically optimal rates of N fertilization". Measured *ex post* optimal rates are used to estimate *ex ante* optimal rates.

The most commonly used alternative method is the balance sheet method, which involves calculating "N fertilizer needs" by using a simplistic model of all processes that occur in soils. Nitrogen recommendations based on yield goals and N fertilizer credits use this method.

- What is contained in the model (and the rate considered "best") is determined by processes that are often more political than scientific.
- The estimates of optimal rates are not directly linked to profits for producers. The profits lost by not using most profitable rate cannot be calculated.
- Producers have no way to evaluate and improve estimates of optimal rates calculated by this method.

Other methods for estimating optimal rates include doing what seemed to work last year, what a neighbor did, or what was suggested in an advertisement.

Statement of EQIP Eligibility

The Iowa Soybean Association states that each individual or entity receiving a direct or indirect payment for any structural, vegetative or management practice through this grant in compliance with the adjusted gross income and highly erodible lands and wetlands conservation compliance provisions of the Farm Bill.

Potential for transferability of results:

There are several areas of potential advancement

First, most of the growers involved have never been enrolled in EQIP. This project used a model that illustrates how partnerships can be used to dramatically increase programming without increasing NRCS staff or staff workloads.

Second, this project shows how the 9th step of the NRCS planning process can be done in relation to N management planning.

Third, although only one year of information has been collected, some trends are already being identified that are not currently being addressed by the general nutrient guidelines used for nutrient management planning. Changes need to be made in NRCS planning to go off of data and results, not just generalized planning guidelines.

Conclusions

Market Incentives

It was easy to get growers to sign up for the market-based incentive program. This project required participating growers to use 100 lbs N or less, with a per-acre incentive payment for their fertilizer reduction. Our phones rang off the hook with calls from people ready to participate. However, two important observations were made:

1. Many of the growers asking to participate were already using 100 lbs N or less for corn production.
2. It was difficult for many growers who did change their practice for this program to feel comfortable with continuing on with reduced rates because of the lack of yield comparisons in the fields to show whether it really worked better.

So while it was easy to achieve the target for the number of growers participating in the reduced rate program with this incentive system, the cost of the achieving these N use reductions a per acre basis was very expensive, especially considering the small impact this had on changing behavior. Replicated strip trials, which make comparisons between N rates in the same field, have been far more effective in influencing behavioral change. At the same time, these are much less expensive to execute.

The result is that we have dropped our interest in market-based incentives as executed in this grant and focused on including incentives the in-field evaluation component. It is far more effective at documenting economic value than paying for a change without evaluation. Growers need to be able to contrast their current practice with an alternative in order to be effective at changing behavior.

We believe that proving the benefit is far more effective at changing behavior than implementing a practice without adequate evaluation capabilities. By using replicated strip trials, evaluations can be done on a much smaller scale, at less cost, and with the potential to affect far more people than those just who are directly involved.

Evaluations – Individual vs Pooled

We also noticed a difference between growers who had only their own information from guided stalk nitrate testing when compared to growers who had access to the evaluations from other growers in their area to compare and contrast with their own information. While the original idea was that feedback on a given field would be beneficial, the impact on the growers was much greater when their data was combined with other data from their general area.

A change in protocols is needed to better capture pertinent management information. It is critical, however, that methods to pool the data keep all grower confidential.

Technical Expertise in Evaluations

Access to training on how to evaluate N nutrient management is very limited. The proper use of the tools used has been a major impediment. But the larger barrier continues to be the lack of expertise in interpreting the evaluation. It is clear that guidelines and training must be developed on how to use the evaluation information. Until now, all emphasis on nutrient management training has been in planning, rather than addressing how to evaluate and incorporate feedback data.

A frequent mistake in interpreting the stalk nitrate test results has been the inability to distinguish between N sufficiency and N use efficiency. By using the guided stalk sampling for just one field with a constant management practice, we can determine N sufficiency in that field. That is, we can tell whether the crop had enough N for profitable grain production. What this cannot do is determine whether the current practice was the most efficient in getting adequate yield from the plant. In other words, the management practice may have involved using a very high rate of N and the stalks may have had adequate N, even though more than half of the N applied was lost. Conveying the difference between the two concepts is a challenge and difficult to address when done at only an individual level.

Best Management Practice (BMP)

We are frequently asked to identify a BMP from one year of evaluation. The results of one year of testing shows there is no BMP that works for all in terms of a given rate, form, timing, placement or the N protection it offers. Something this project did identify is the need to expand evaluation of current nutrient management programming within the NRCS, and in other organizations and agencies, as well.

The ninth step of the NRCS planning process is evaluation. NRCS should be focusing on evaluation as a key BMP for nutrient management programming.

At this time in Iowa, official BMPs for nitrogen use are based on NRCS's interpretation of Iowa State University recommendations, which distinguish only rate, crop rotation and differences in manure types. The data collected in this particular year, while only a single year, can identify problems with the current concept of BMPs.

NRCS vs ISU Recommendations

Iowa State University publication pm 1714 is referenced in the 590 standard for Iowa. It clearly states that "The end-of-season (stalk nitrate) test essentially asks if the corn crop had too little, too much, or optimal amounts of N. The resulting information can be used to evaluate the reliability of the soil test or any other system of making N recommendations. When used over a period of several years, information provided by the cornstalk nitrate test can be used to help select rates of N application that are most appropriate for the soil factors and management practices that make sites differ in N fertilizer requirements."

Despite the NRCS 590 code stating an adherence to ISU recommendations, the current plans do not permit adjustments based on stalk nitrate sampling as stated in the recommendations above a preset amount. NRCS focuses exclusively on the general planning, not the evaluation or adjustment. There is adisconnect between the concept of paying for an evaluation tool, like the stalk nitrate test, and then not being permitted to use it. Evaluation of nutrient management using tools like guided stalk nitrate test and the replicated strip trials is paid for under EQIP, but adjustments based on the outcomes of using these tools are not permitted unless they are compliant with the original planning guidelines. The range of evaluation data generated by growers using these tools show a clear need for NRCS to adjust nutrient planning guidelines to allow for factors other than only rate, crop rotation and manure source.