La venue de ce conférencier a été rendue possible grâce au soutien financier du ministère de l’Agriculture, des Pêcheries et de l’Alimentation

Agriculture, Pêcheries et Alimentation

Québec

Un partenaire de premier plan !

Explaining Variability in Yield Response to Nitrogen

New Opportunity for Soil and Crop Variability Management, Quebec, Canada

Peter Kyveryga, PhD

Operations Manager-Analytics

Iowa Soybean Association

Outline

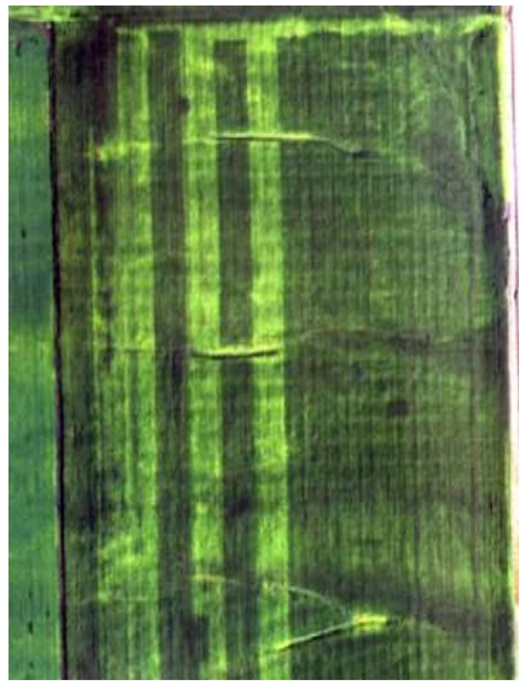
- Temporal patterns of corn N deficiency and mid-season N recovery.
- Variability in yield response and reducing uncertainly in economic optimal N rates.
- On-farm approaches: Decision support systems to quantify and manage risk in N management.

Common Risks in N Management

N loss

Yield loss

Reduced N availability due to lack of moisture

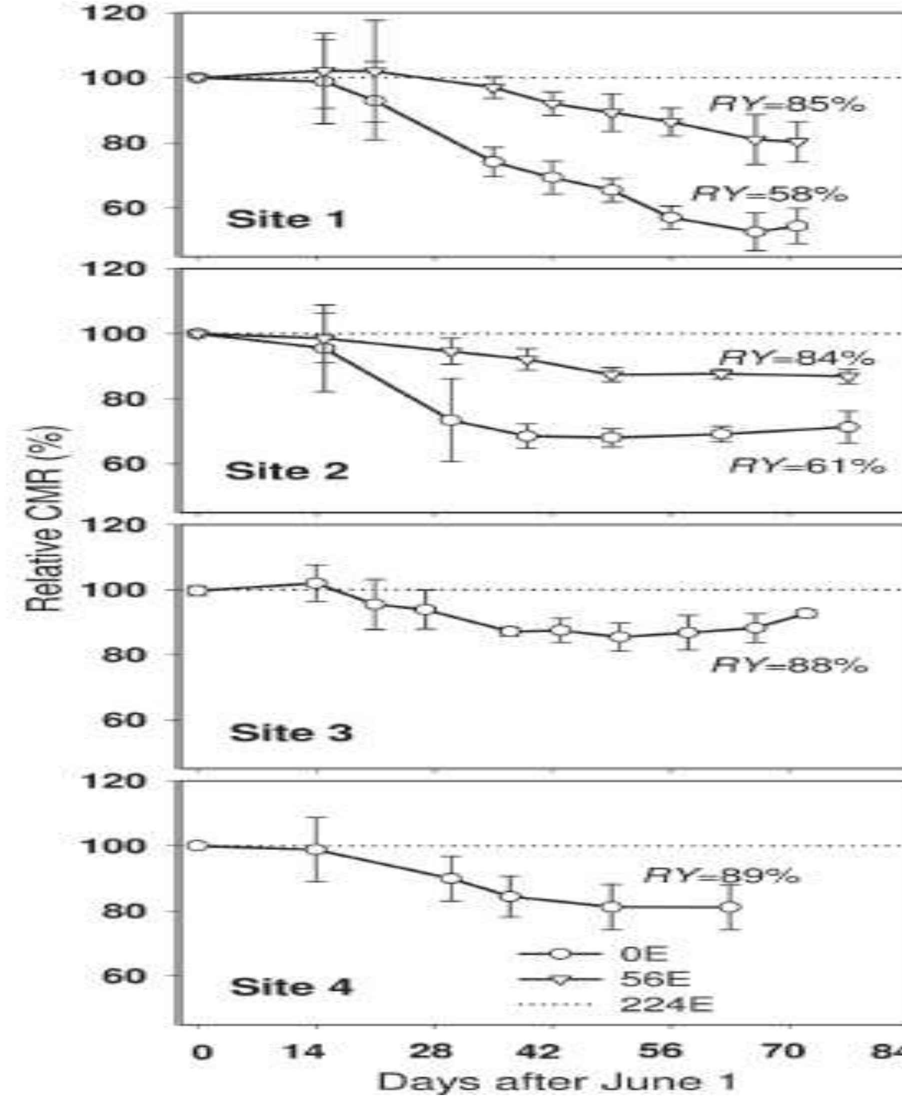


In normal rainfall conditions:
Under or over N applications or large unexplained variability.

In-Season N Adjustments Using SPAD Meters

- Chlorophyll Meter Readings (CMR)
- 4 sites
- 0, 56, 122, 224 kg N/ha

sidedress UAN at V2-V3



Convergence of Chlorophyll Meter Readings

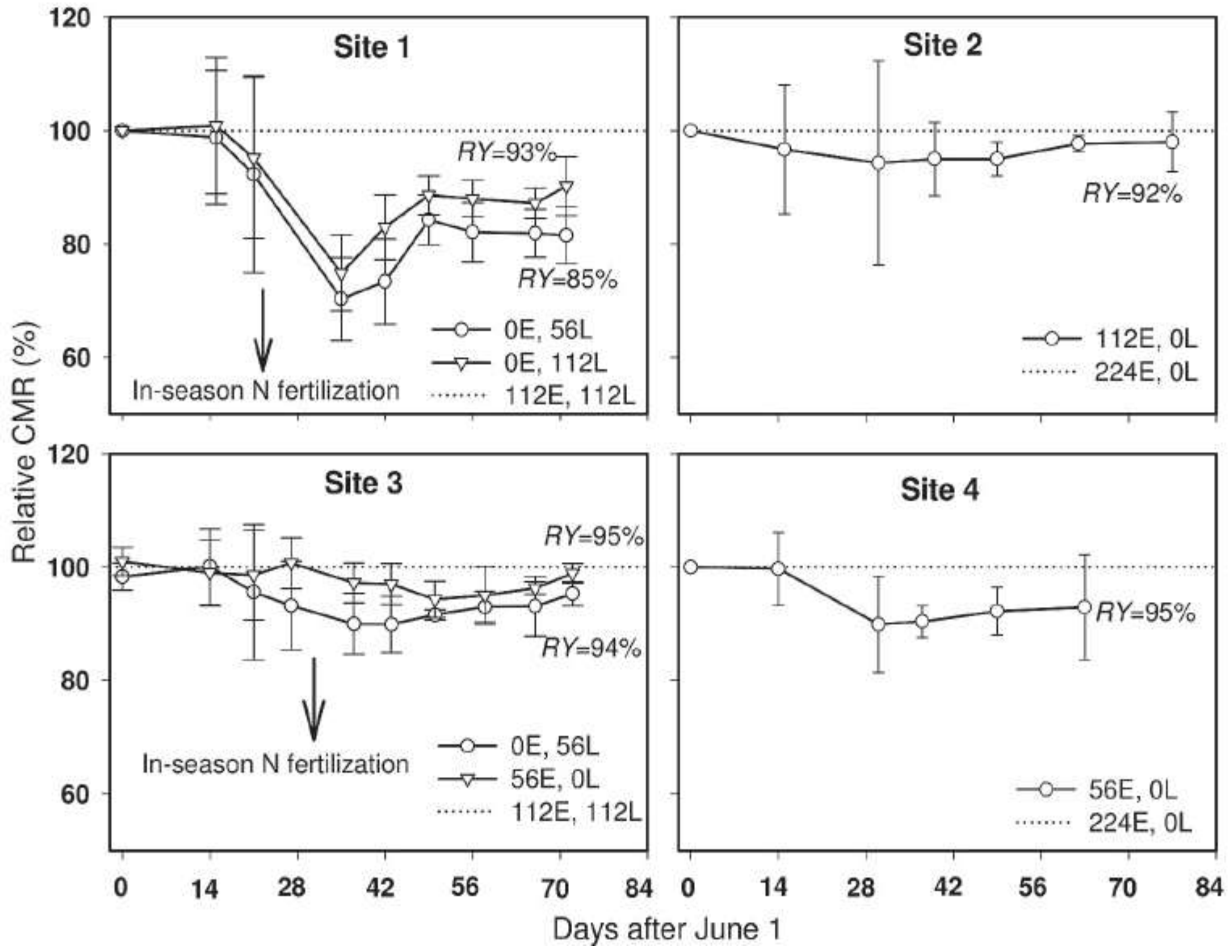
Dribbled UAN at V10-V13

- Site 1 and 3:

56 and 112 kg N/ha

- Site 2 and 4:

56 N/ha



Only treatments with yield reduction >5% from the highest rate.

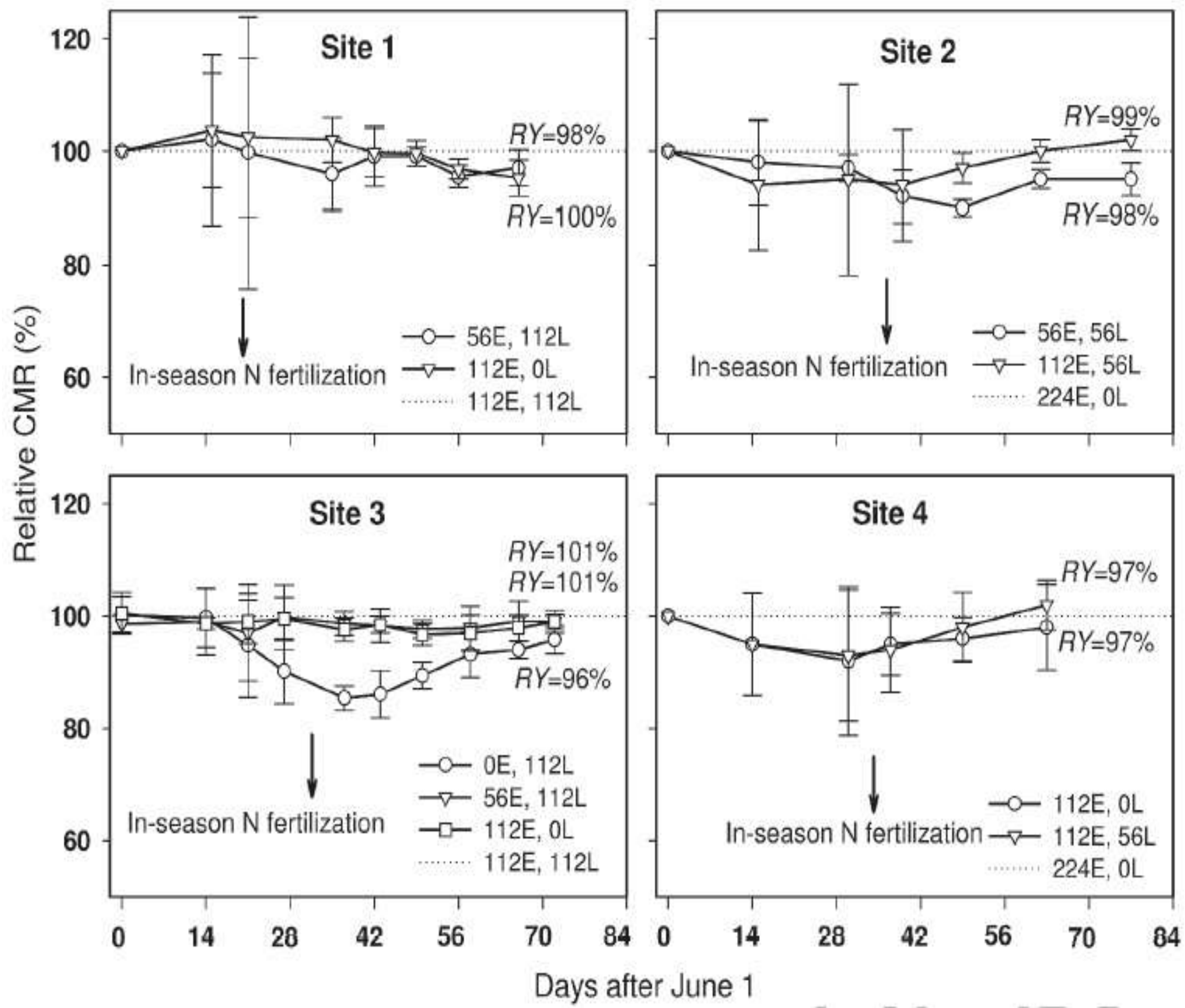
2007. Agron. J. (658-664)

Mid-Season Recovery from N Deficiency

Only treatments that had yields <5% of that of the highest (reference) N rate.

These graphs mimic situations when N rates are well established and there is concern that farmers apply more N than it is needed.

CMRs tented to converge with those from the highest rate.

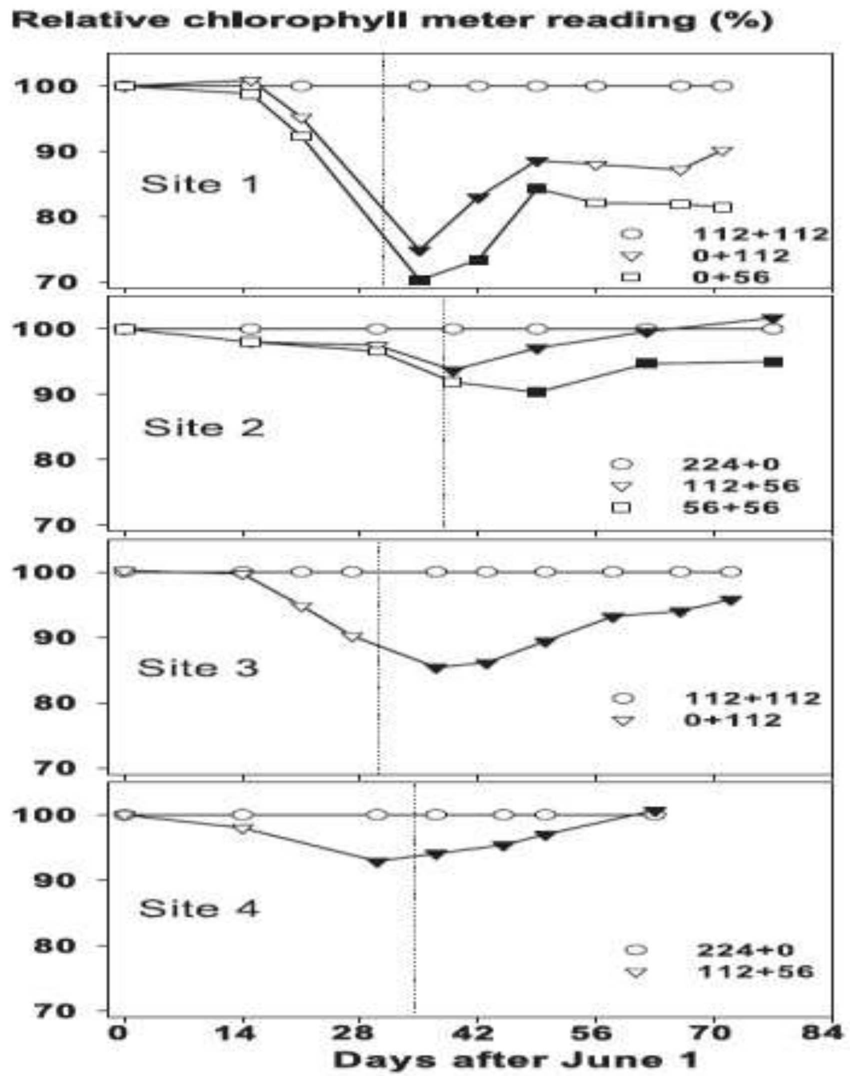


2007. Agron. J. (658-664)

Mid-Season Recovery from N Deficiency

In-season N applications caused CMR to converge during reproductive stages with those that have the adequate supply of N.

Solid dots indicate statistically significant increases.



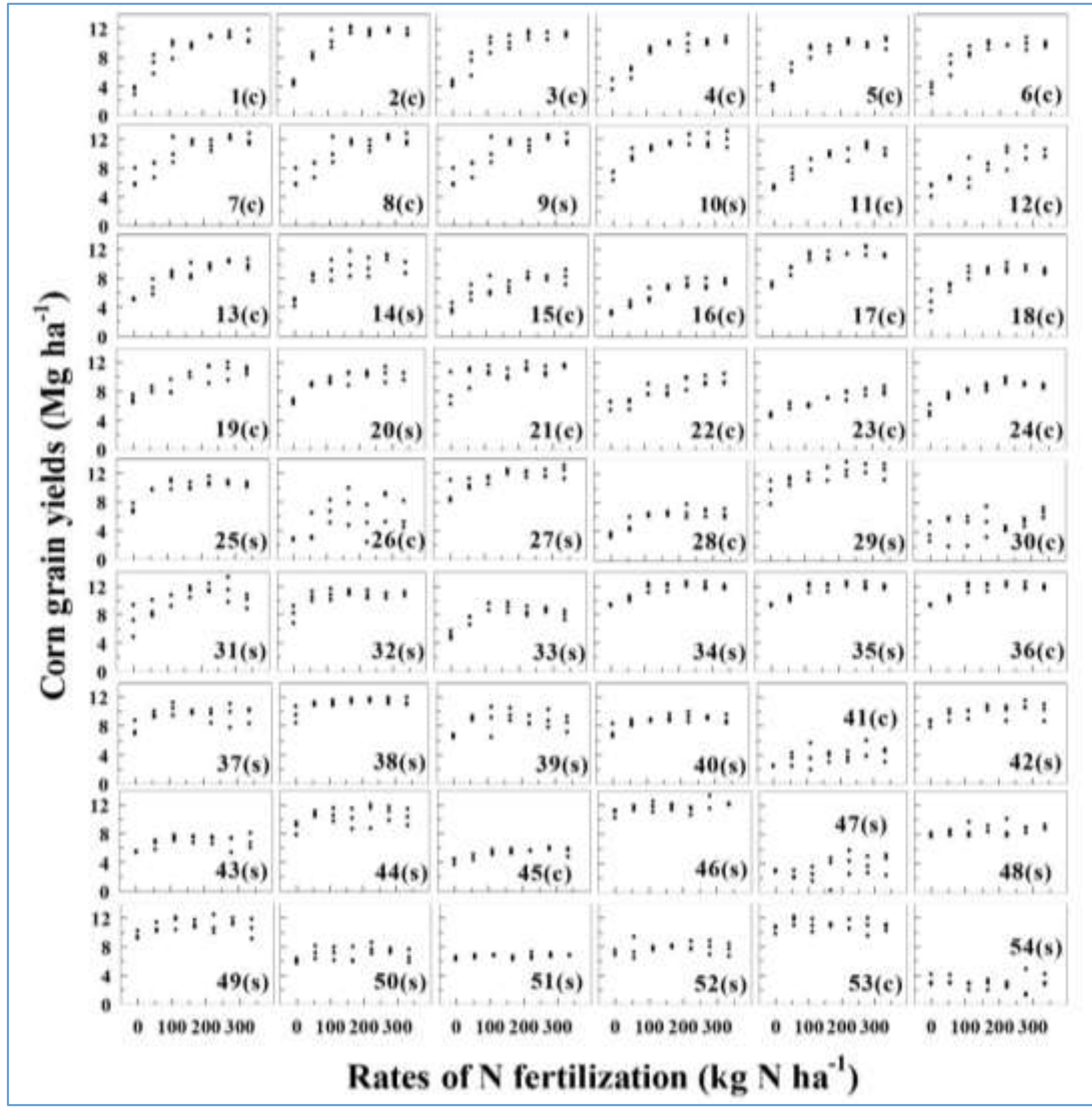
2007. Agron. Sustain. Dev.

Challenges with In-Season N Diagnostics

- Chlorophyll meters can detect easily severe N deficiencies (> 10% yield reduction) but unlikely mild mid-season N deficiencies.
- Corn canopy greenness could partially recover from short periods with inadequate N.
- In-season increases in N rates tended to produce increases in CMR but without significant yield response.

Challenges in Developing N Recommendations

Dr. Alfred Blackmer, professor of Iowa State University, had this poster in his office and told me that he could not develop reliable after-the-fact N recommendations across all trials.

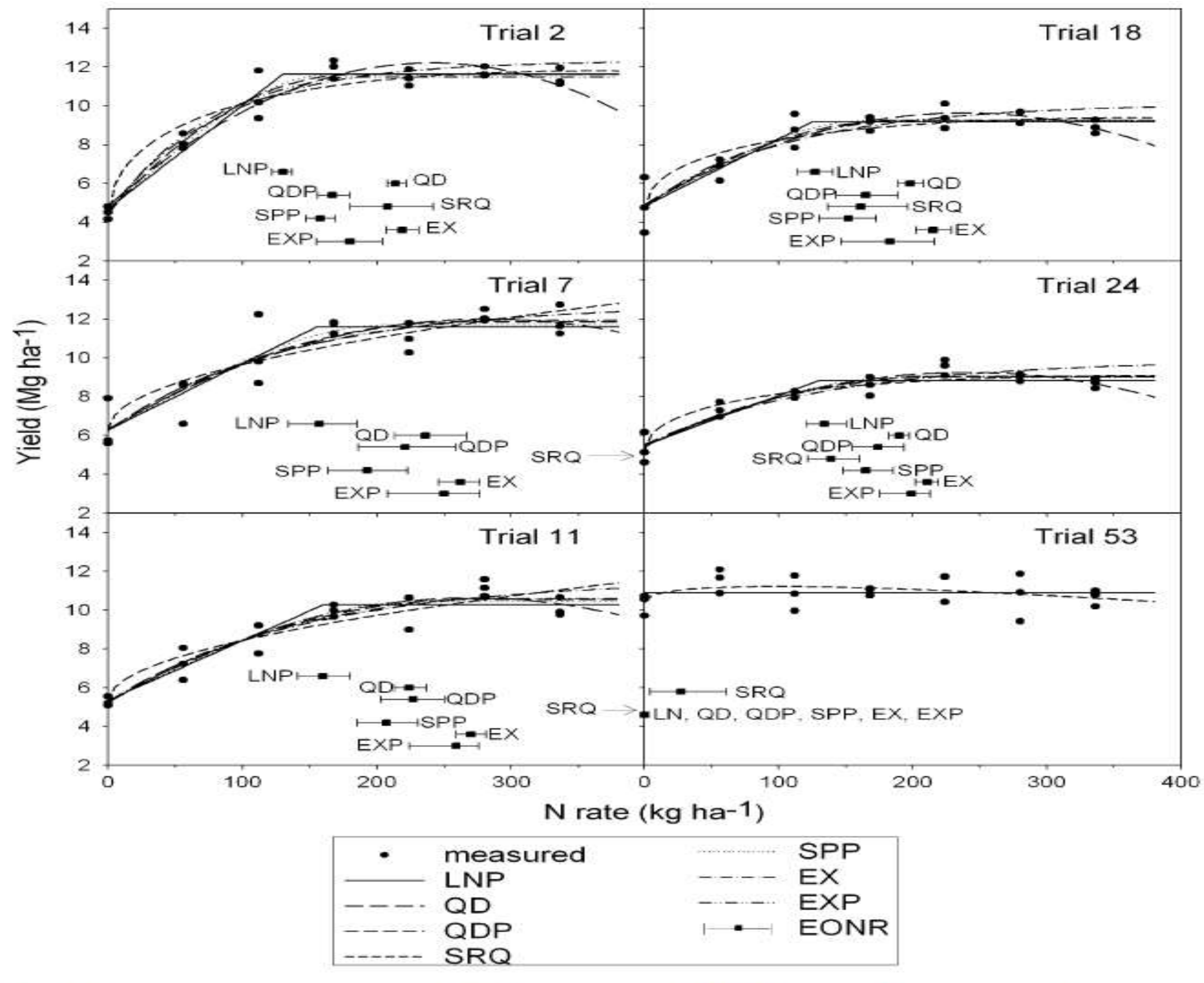


Uncertainty in Economic Optimum N Rates

Example of "Model bias" and estimating 68% Confidence Bands for EONR calculated by different models.

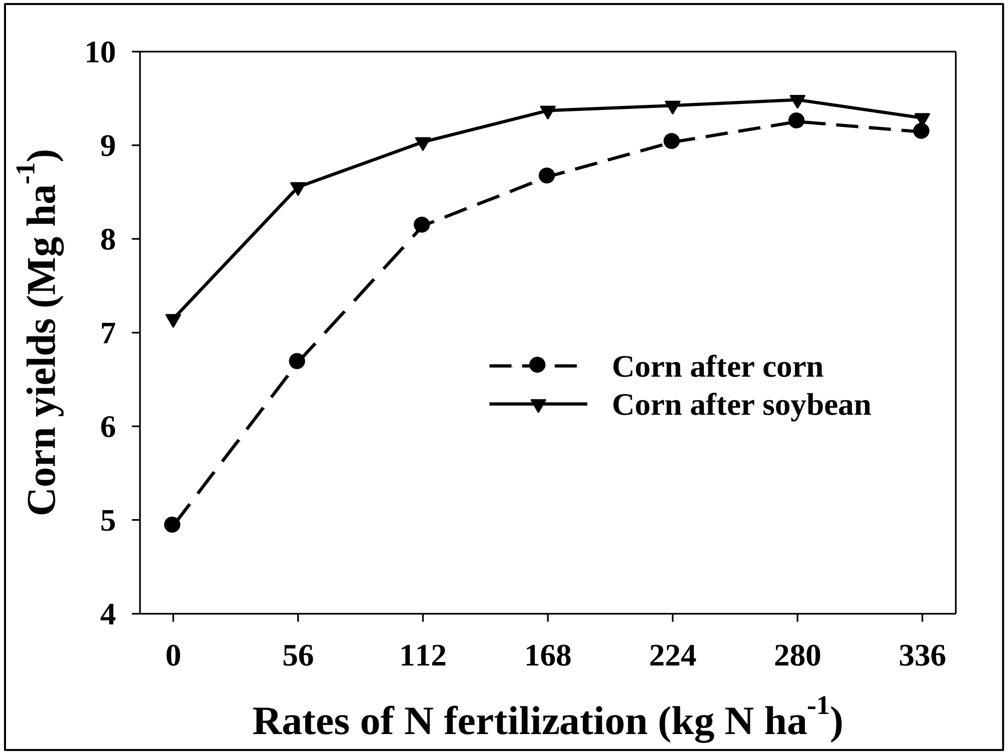
Small changes in slopes produce significant differences in EONR.

How to solve this problem?



Jaynes. 2011. Precis. Ag.

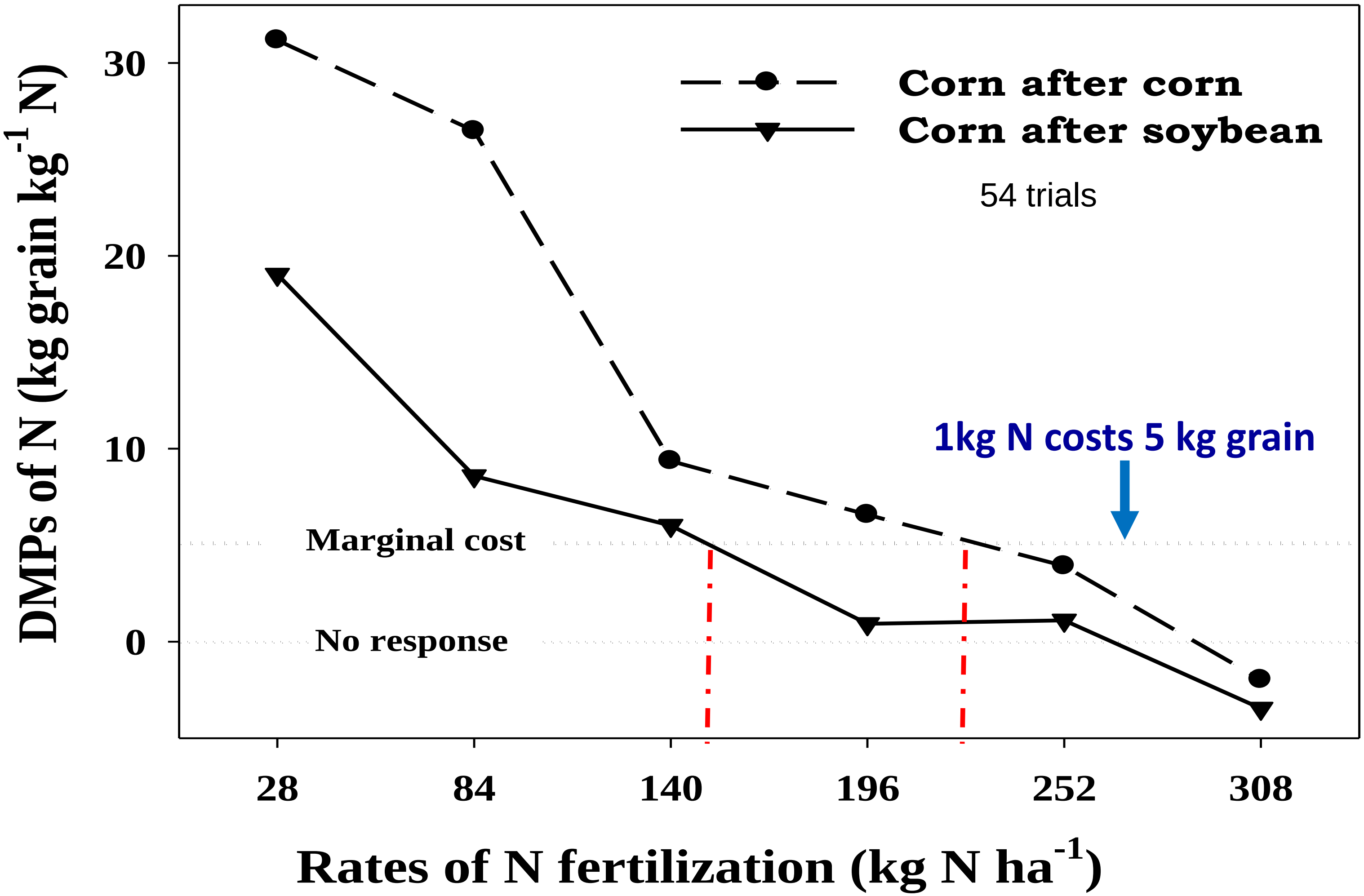
Discrete Marginal Analysis of Yield Response



Discrete marginal product- is yield response per unit of N.

$$DMP_i = \frac{Y_{N1} - Y_{N2}}{N1 - N2} = \frac{\Delta Y_i}{\Delta N_i}$$

Discrete Marginal Analysis



2007. Agron. J. (1048-1056)

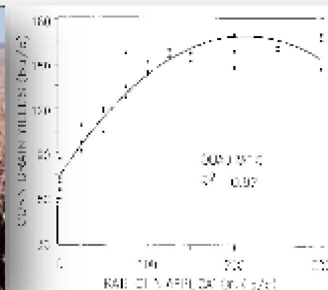
Improving After-the-Fact N Recommendations

- Using Discrete Marginal Analysis (i.e, analyses of model slopes).
- Using other benchmarks for EONR such as rates that produce different % return on the last unit of N.
- Using management categories across many trials to reduce variability in yield response.
- After-the-fact EONR are required to make predictions for the future.

Needs To Estimate Risks in N Management

After-the-Fact

Description

For-the-Future

Prediction and Prescription


Uncertainty and Risk

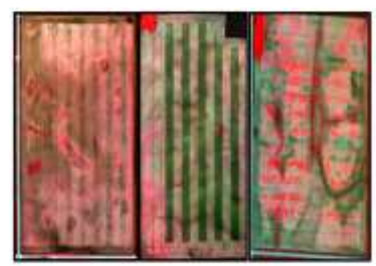
LOW **HIGH**

Risks and uncertainty in soil spatial variability, weather, differences in management, market prices, technological constraints and etc.

ISA On-Farm Network®

- On-Farm Network organizes farmers to use precision ag. technologies to evaluation management practices in crop production.

- We work annually with ~ 400 farmers in Iowa and provide technical assistance to similar groups in Minnesota and Indiana.



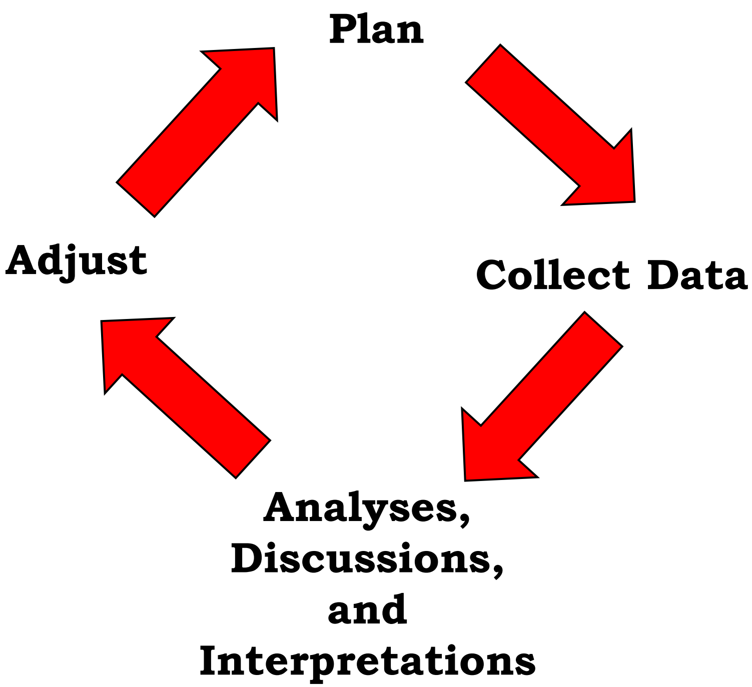
Adaptive Management/Participatory Learning

- A process of evaluating and improving management by:

✓conducting on-farm studies and collecting critical management, soil and weather information;

✓sharing and discussing results with other farmers, agronomists, crop consultants, and scientists;

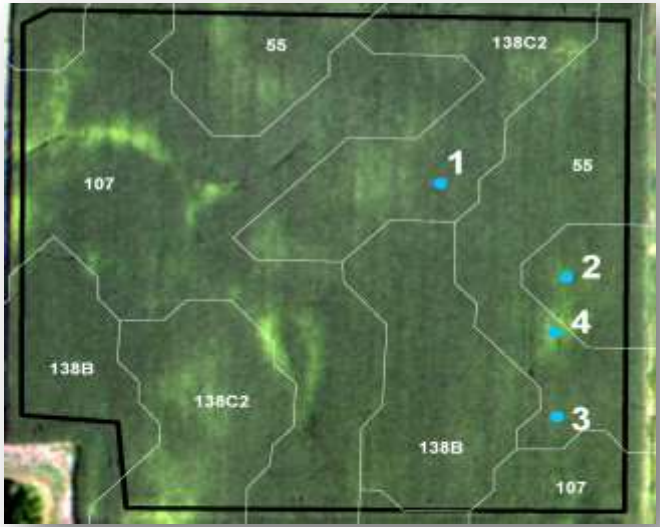
✓ and making adjustments for the future.

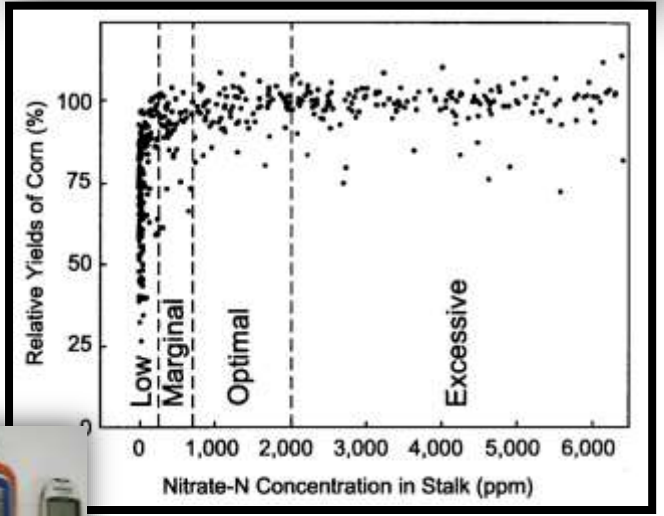


Post Season Feedback in Corn N Status

- **Tools to collect feedback in N status:**

1. Late-season digital aerial imagery.
2. Corn stalk nitrate test (CSNT).
3. On-farm replicated strip trials (RST).





Iowa State Univ. PM 1584

All Results of On-Farm Evaluations Are On-Line

Imagery Guided Stalk Nitrate Survey

2013 Stalk Nitrate Results

GSS2013IACD018

Stalk Nitrate Levels (By Category)
- Low (<250 ppm)
- Marginal (250-700 ppm)
- Optimal (700-2000 ppm)
- High (>2000 ppm)
- Soil Survey

Total N (lbs/a)	N Form	N Timing	Previous Crop	County	Tillage	Image Date	*GeoMean ppm NO3
140	UAN	SP	Corn	Bremer	Spring Only	9/3/2013	45
Month		March	April	May	June	July	August
Rainfall (in.)		1.8	4.8	9.6	6.2	2.3	2.6

*GeoMetric Mean ppm of NO3-N includes points 1, 2 & 3 but not targeted deficient point 4.

Two-Treatment Replicated Strip Trials

Strip Trial Summary Statistics

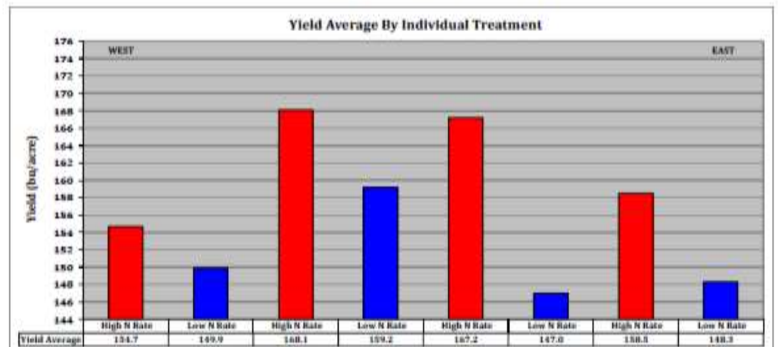
Mitchell County, IA

ST2013IA115B

Yield By Treatment and Soil Map Unit

Soil Map Unit	Label	Percent of Trial: High N Rate	Percent of Trial: Low N Rate	Yield (bu/acre): High N Rate	Yield (bu/acre): Low N Rate	Yield* Difference
Waubeek Silt Loam, 0 To 2 Percent Slopes	771	36.5	35.7	166.7	153.6	13.1
Waucoma Silt Loam, 0 To 2 Percent Slopes	913	4.9	3.6	144.5	143.6	0.9
Ostrander Loam, 0 To 2 Percent Slopes	394	4.5	6.4	160.2	160.6	-0.4
Bassett Loam, 2 To 5 Percent Slopes	171B	3.4	2.4	158.4	141.0	17.4
Racine Silt Loam, 2 To 5 Percent Slopes	402B	0.8	1.7	97.4	92.7	4.7

*Yield differences calculated for Soil Map Units that have relatively small areas might not be accurate.



Yield Average for All Individual Treatments (bu/acre)	High N Rate	Low N Rate	Yield Difference	A randomization test suggested strong evidence of a significant yield difference.
	162.1	151.1	11.0	

On-Line Database of Replicated Strip Trial Summaries

On-Farm Network® Replicated Strip Trial Database

Instructions

Limit trial results as desired by selecting one or more Years, Crop, Trial Type, Trial Detail, Watershed and County.

Hold the CTRL key and click to select multiple items.

After making all of your selections click Display Results.

If you choose just one crop you will see the average yield difference and also have the option to calculate ROI on the trials.

To reset your selections click Clear Results.

Year

- All Years
- 2013
- 2012
- 2009
- 2007

Crop

- All Crops
- Corn

Trial Type and Detail

- Crop Protection - Seed Treatment
- Equipment
- Management
- Plant Nutrition - Fertilizer
- Plant Nutrition - Manure
- Plant Nutrition - Manure + Nitrogen
- Plant Nutrition - Manure Form
- Plant Nutrition - Nitrogen Form

- All Trial Details
- NH3 vs Byproduct
- NH3 vs ESN

Location

- All Watersheds
- Boone
- Middle Des Moines

- All Counties
- Greene
- Wright

Display Results

Clear Results

http://www.isafarmnet.com/onlinedb/index.php

On-Line Database of Replicated Strip Trial Summaries

Year	Watershed	County	Crop	Trial Type	Trial Detail	Yield Difference bu/A	Trial ID	Trial Report	Stalk Nitrate Report	Scouting Report
2013	Upper Iowa	Hancock	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	22.3	ST2013IA071A	View	View	
2013	Upper Iowa	Hancock	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	2.0	ST2013IA072A	View	View	
2013	Winnebago	Hancock	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	2.0	ST2013IA070A	View	View	
2013	Upper Iowa	Hardin	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	-1.5	ST2013IA012A	View	View	
2013	North Skunk	Jasper	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	22.8	ST2013IA121A	View	View	
2013	Flint-Henderson	Lee	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	23.9	ST2013IA278A	View	View	
2013	Boyer	Monona	Corn	Plant Nutrition - Manure + Nitrogen	Expanded Manure	0.0	ST2013IA148A	View		

Average Yield Difference of the 7 trials displayed: **10.2** bu/acre.

90% Confidence Interval for the Average Yield Difference: from **2.7** to **17.7** bu/acre.

Return on Investment

To calculate ROI of the selected trials, enter a market price for this crop and the cost per acre.

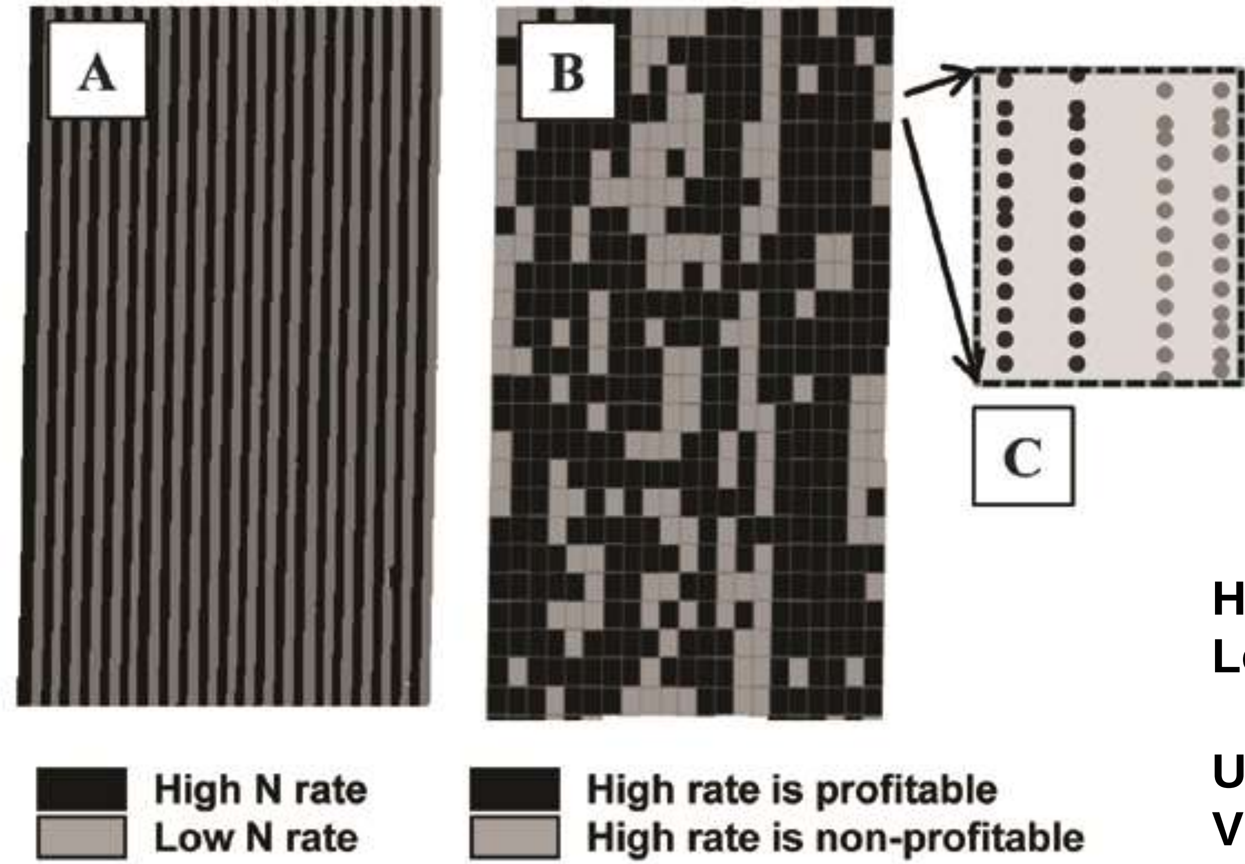
Market Price: $ 4.5

Cost Per Acre: $ 25

Average Return on Investment: **$20.90** per acre.

90% Confidence Interval for the Average Return on Investment: from **$-12.85** to **$54.65** per acre.

Case Study: Soil-Based Variable N Applications



30-m grid cells

High-140 kg N/ha
Low-128 kg N/ha

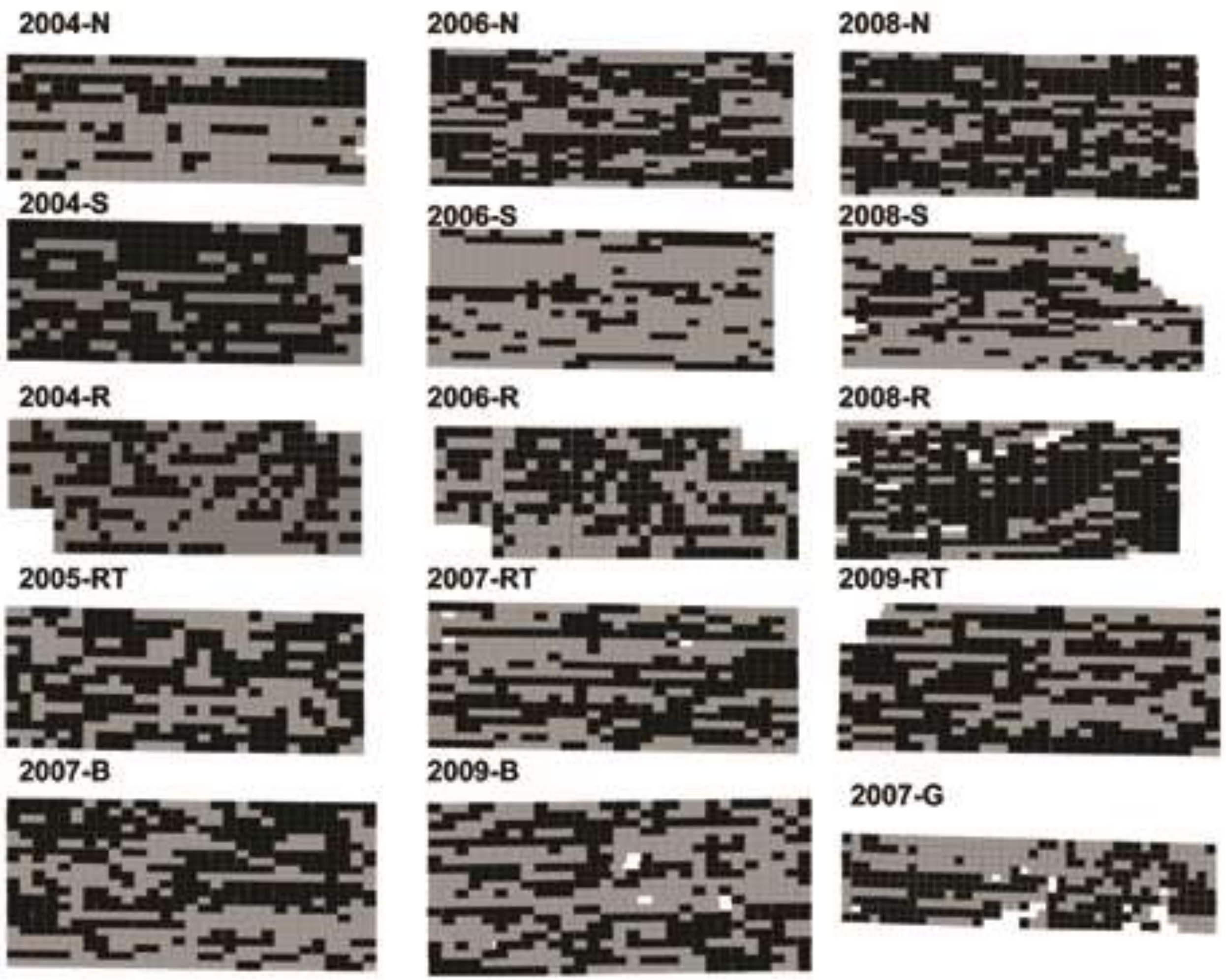
UAN sidedress at V2-3

<u>Categorical Analysis of Economic Yield Response?</u>

1) **Reducing influence of yield monitor errors;**
2) **"Yes" or "No" are common decisions to apply additional N.**

2007. Agron. J. (796-804)

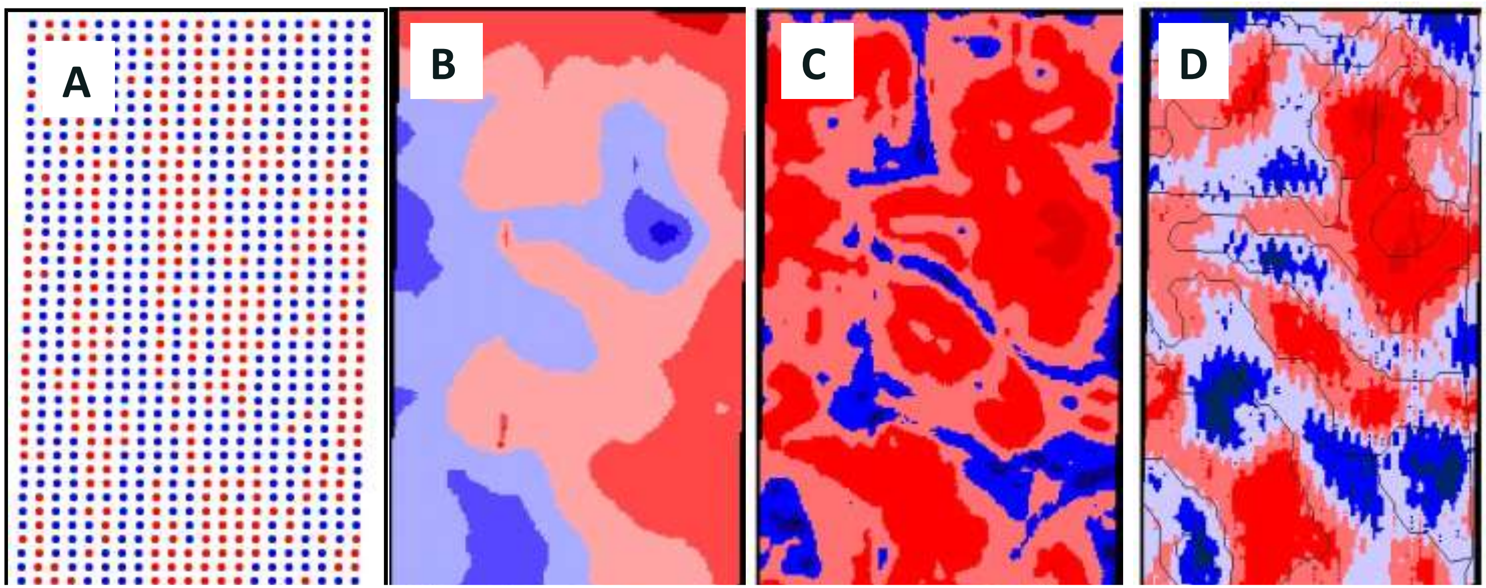
Spatial Categorical Analysis



High rate is profitable
High rate is non-profitable

Profitability Maps, Topography and Soil Attributes

Profitability Map | **Elevation** | **Topographic Wetness Index (TWI)** | **Soil Electrical Conductivity and Soil Map**



High N rate is profitable
High N rate is non profitable

High ground
Low ground

High probability of flooding
Low probability of flooding

High conductivity
Low conductivity

Autologistic (Spatial) Regressions

Year-Field	Relative elevation	Soil electrical conductivity	Slope	Topographic wetness index
2004-S				↓
2004-R	↑			
2005-RT				↓
2006-N			↓	
2006-R		↓		
2007-B		↑		
2008-S			↑	
2009-RT	↓			

↑ **-increase in variable caused higher probability of profitable yield response.**

↓ **-increase in variable caused lower probability of profitable yield response.**

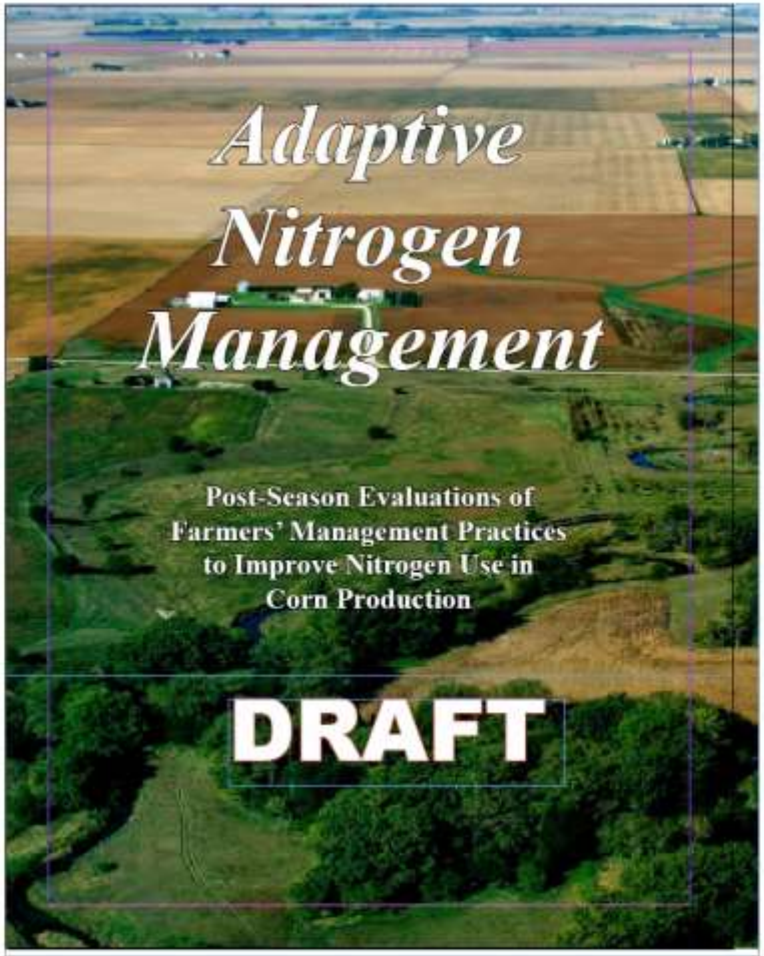
2007. Agron. J. (796-804)

Yield Response and Spatial Soil Properties

- We could detect significant effect of spatial soil variables on the probability of profitable yield response only in 8 of 15 sites.

- These effects were not consistent over years.

Developing Decision Support **System**



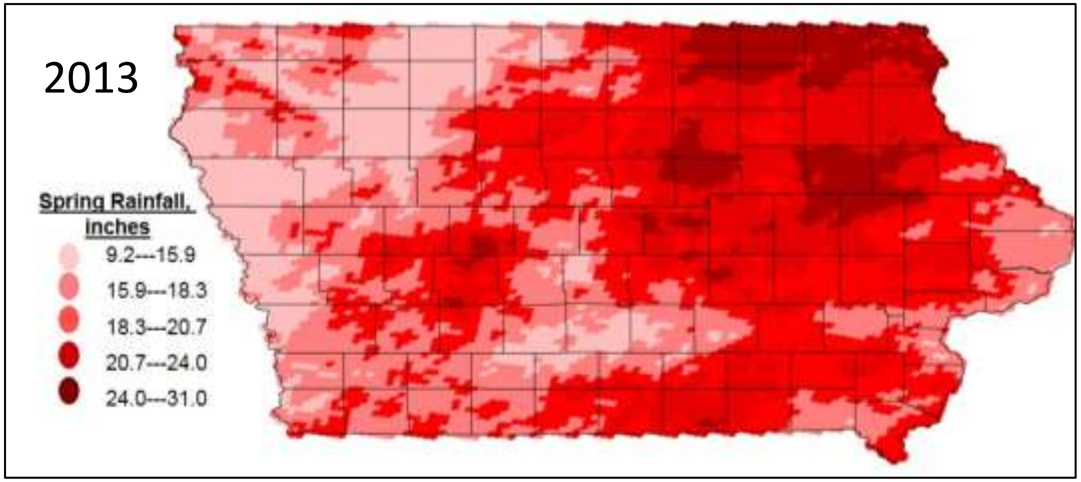
Content:

Three-Level Decision Support System

<u>Using N Feedback for Future Adjustments in N Management</u>

1. Feld-level site-specific early-season rainfall observations and post-season corn N status.
2. Benchmarking N management against N Rates that Resulted in Optimal N Status across state or watershed.
3. Using Multilevel Analysis and Posterior Predictive Probabilities of Yield Response to N.

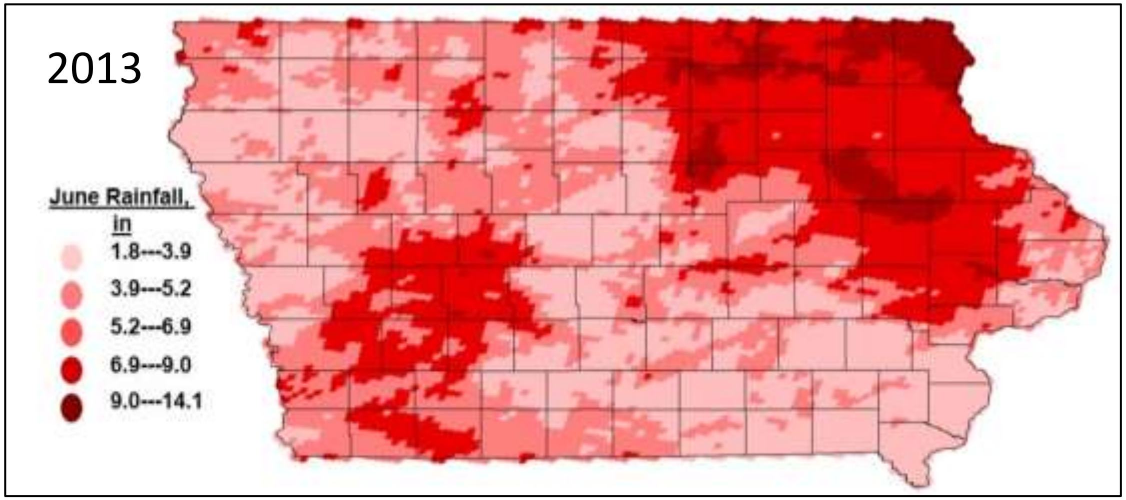
Early Season Rainfall and Risk of N Loss



4-km rainfall grids

<u>Assessing Risk of N Loss using March through June rainfall</u>

Relatively High > 35 cm
Relatively Low < 35 cm



www.mesonet.agron.iastate.edu

Future N Adjustments using N Feedback

Using risk of N loss and post-season corn N status.

Field-Average N Status*	After-Fact Risk of N Loss#	Adjustments for Future Management
Deficient	Above Average	No adjustments or in-season testing for possibility to correct N deficiency
	Average	Increase N availability
	Below Average	Increase N availability
	Very Low (drought)	No adjustments
Optimal	Above Average	No adjustments
	Average	No adjustments
	Below Average	No adjustments
	Very Low (drought)	No adjustments
Excessive	Above Average	Reduce N rate
	Average	Reduce N rate
	Below Average	No adjustments or in-season testing for possibility to reduce N rate
	Very Low (drought)	No adjustments if corn N uptake increased due to moisture stress.

*When geometric mean of 3 stalk samples fall into deficient, optimal or excessive category.

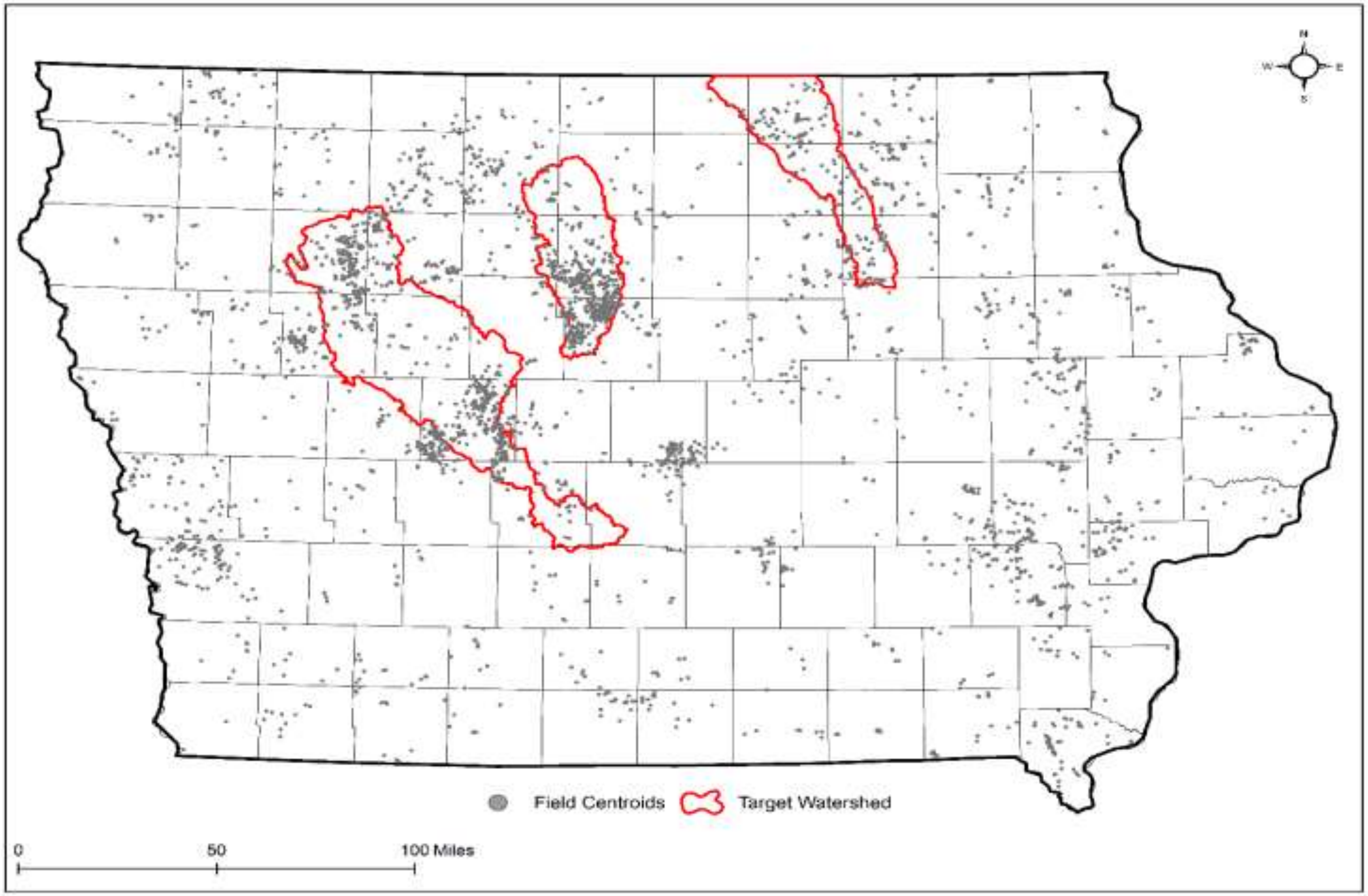
Above-average; more than 14 inches from March through June rainfall.

Five N Management Categories

1. AA Fall; fall-applied anhydrous ammonia.
2. Swine Fall ; fall-injected swine manure.
3. AA Spring; spring-applied anhydrous ammonia.
4. UAN Spring; spring-applied UAN.
5. UAN SD; sidedress UAN

2011. JSWC. 66:373-385

Analysis of Historical Data: 2006-2013

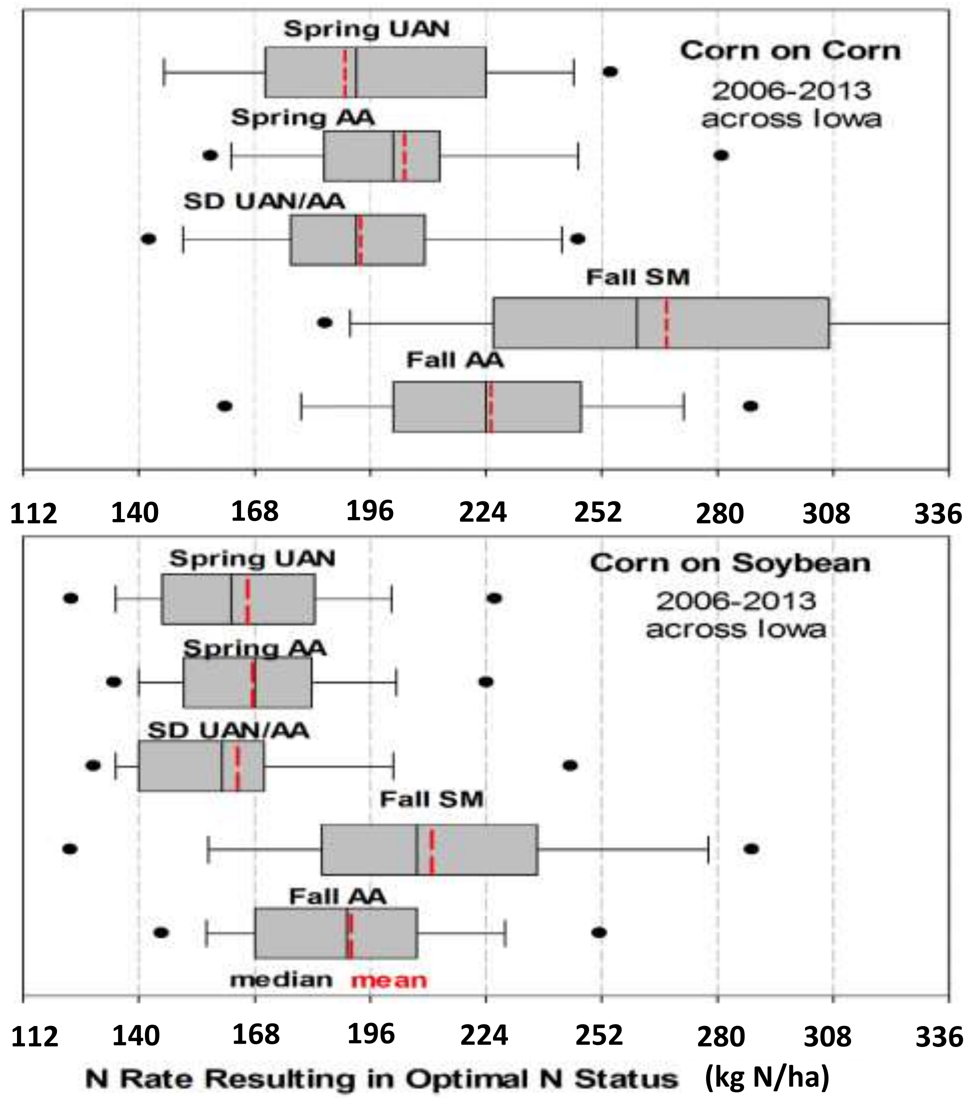


3430 corn fields from 2006 through 2013

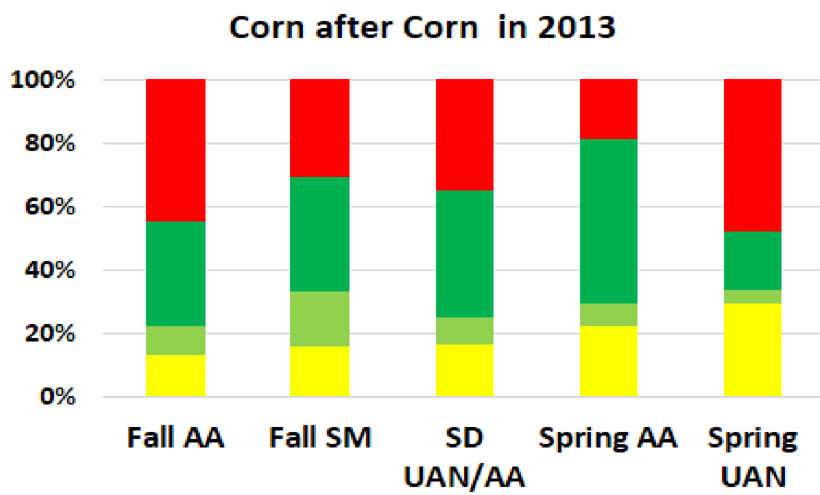
Benchmark N Rates Resulting in Optimal Corn N Status

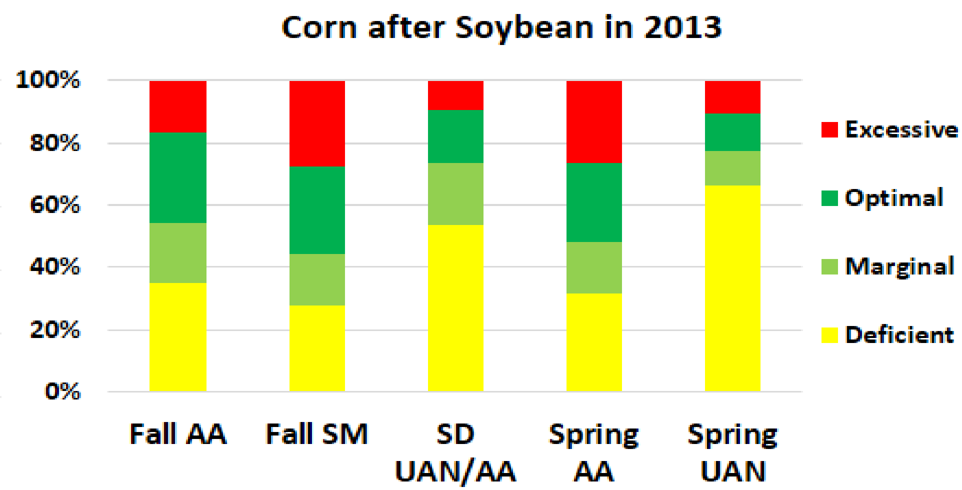
- If farmers do not collect site-specific N feedback and their N rates fall on the right side of the box, then possibility of decreasing N rate or use in-season diagnostic tools.

- If farmers' N rates fall outside the box but field specific N status or result of replicated strip trial can verify the optimal N status, no changes in N management.



20013: Corn N Status, Rainfall and N Rates





Average Monthly Rainfall (cm)					
May	22	17	24	28	20
June	12	9	15	17	11
July	2	3	5	5	5
August	3	5	5	7	7

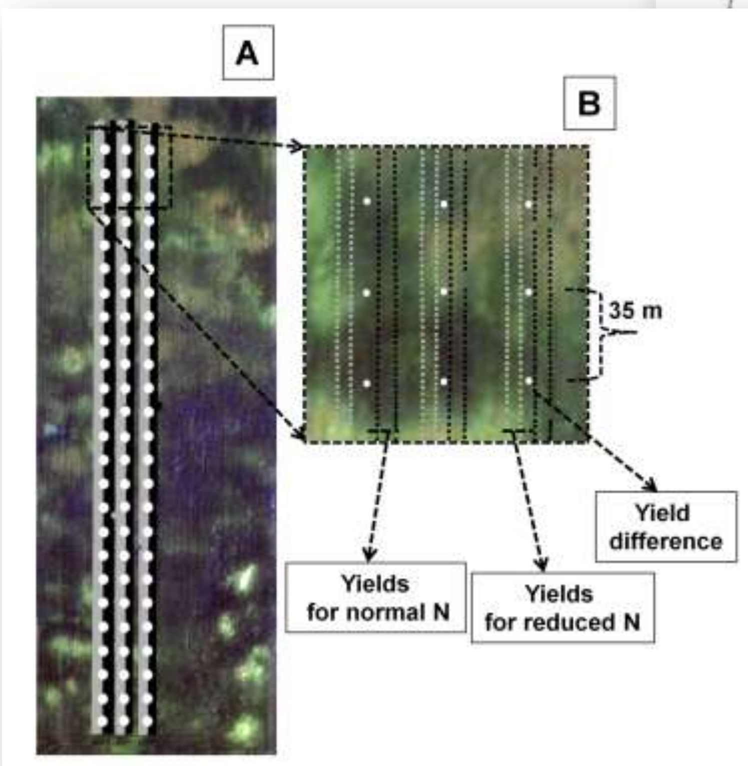
Average Monthly Rainfall (cm)				
23	21	28	26	25
14	11	18	15	15
4	3	6	4	4
4	4	7	5	5

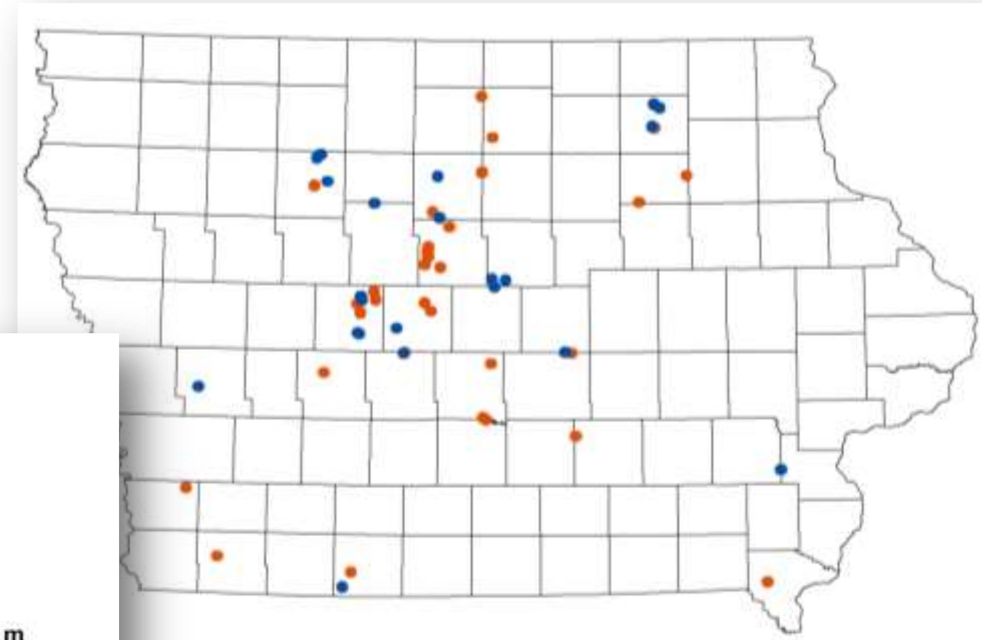
N Rate (kg N/ha)					
Average	224	293	231	196	217
Std. Dev.	36	69	29	13	38

N Rate (kg N/ha)				
192	255	172	170	169
26	75	40	24	38

Reducing Farmers' N Rates

When and where N reductions are possible and at what risk?



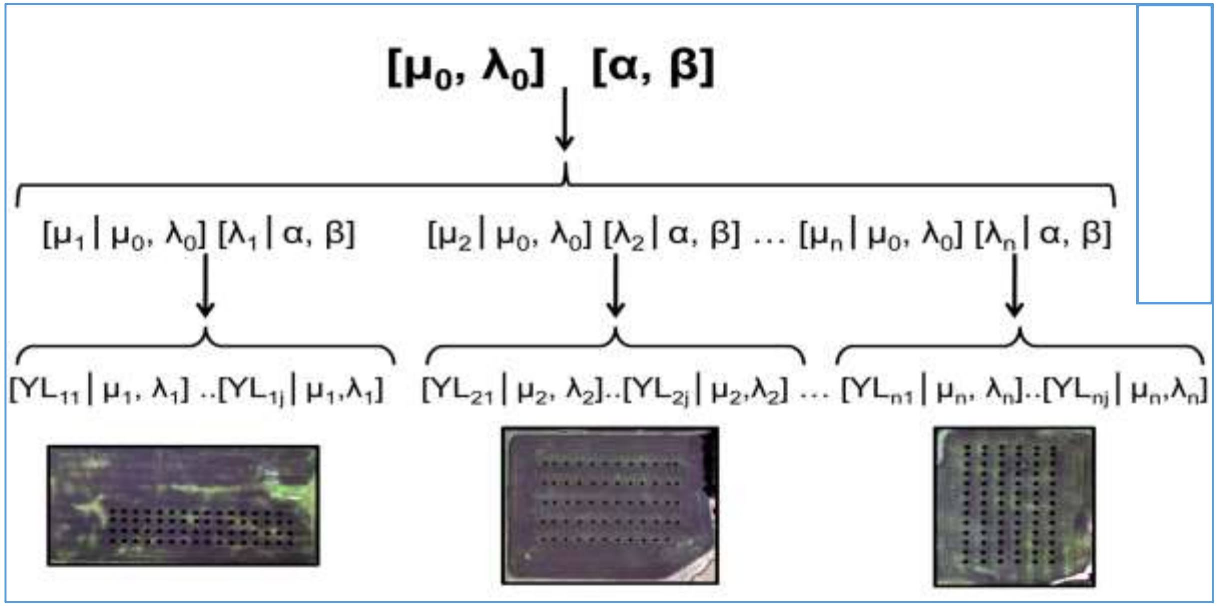


2006: 34 on-farm trials

2007: 22 on-farm trials

Predictions for Unobserved Situations

Hierarchical and Bayesian Analyses



Regional Process Model

Field Process Model

Data

Predictive Posterior Probabilities as the Risk of Economic Yield Loss from Reducing N.

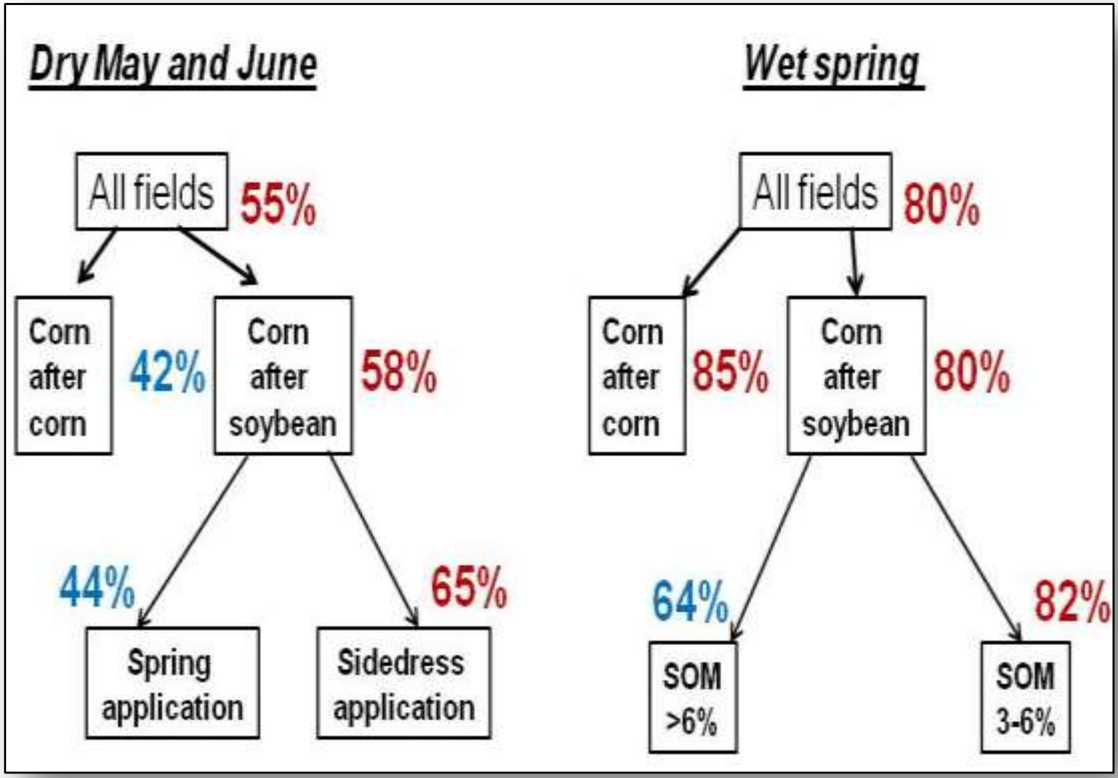
2013. Agron. J. (85-94)

Nitrogen Decision Tree

N categories with lower risks (in blue) are more preferable, especially in years with dry May and June.

These probabilities can be adjusted whether a farmer collects feedback in N status or not.

Predictive Probabilities of Economic Yield Loss From Reduced N by 30% from the Normal



2013. Agron. J. (85-94)

Category Specific N Recommendations

- Quantifying Risk of : (1) N loss, (2) above or below optimal N status, (3) yield loss or (4) under or over applications using rainfall observations.
- Multi-level estimation of predictive probabilities of economic yield response for different N management categories, including timing, form, placement or within-field-level factors.
- Collecting feedback in corn N status from farmers' fields and refining estimated predictive probabilities.

Thank you

pkyveryga@iasoybeans.com