

Tools for in-Field Evaluations of the Nitrogen and Phosphorus Status of Corn

NRCS Webinar – October 2, 2012

Tom Morris, Professor, Nutrient Management, University of Connecticut

Quirine Ketterings, Associate Professor, Nutrient Management, Cornell University

Doug Beegle, Professor, Agronomy, Pennsylvania State University

Peter Scharf, Professor, Nutrient Management, University of Missouri

Jim Camberato, Associate Professor, Agronomy, Purdue University

Introduction

This is the third webinar about Adaptive Nutrient Management (ANM)

ANM is defined by NRCS in the 590 Nutrient Management Standard

Agronomy Technical Note No. 6 describes ANM within the 590 Standard as consisting of strip trials with at least 4 replications (in process of being re-written)

Previous Two Webinars

The first webinar on May 3 provided information about the process of ANM and provided examples of ANM programs

The second webinar on June 7 provided information about basic protocols of on-farm testing using strip trials with 4 replications with yield as the measurement for evaluation



This Webinar

About in-field evaluations using tests and tools that provide information about the nitrogen status of crops in the field

Information about nitrogen status of crop can help interpret yield results from replicated strip trials as part of a NRCS Adaptive Nutrient Management program

One slide about soil testing for phosphorus as a tool to manage phosphorus over the long term

Format for Webinar

Describe tools and tests using examples from research and extension programs in our states

Use data from literature to enhance examples

Need to check with the state extension soil fertility/nutrient management specialist or extension agronomist about which tests and tools are recommended for use in your state

Outline of Webinar

Soil testing for nitrogen: Quirine Ketterings from Cornell and Doug Beegle from Penn State

Corn stalk nitrate testing: Tom Morris, University of Connecticut

Plant sampling and analysis: Jim Camberato, Purdue University

Crop sensors & chlorophyll meters: Peter Scharf, University of Missouri

Soil Testing for Nitrogen

Quirine Ketterings, Cornell University

Doug Beegle, Penn State University

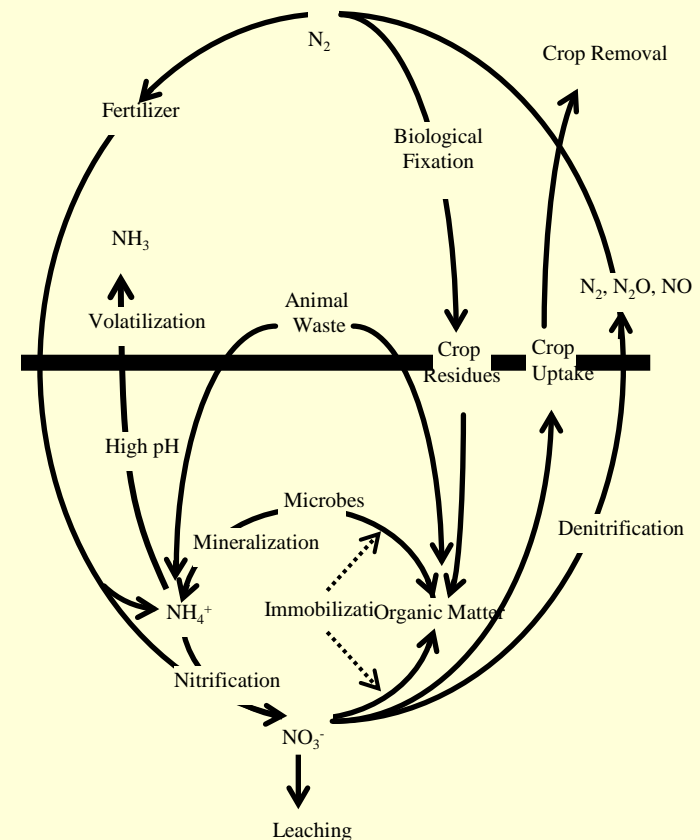
Nitrogen Use Efficiency

- Not just a matter of economy
- Ecological impacts
- We need to do what we can
- It is critical to continue improving N management
- Focus on manure treatment and N fertilizer decisions

Real World N Management

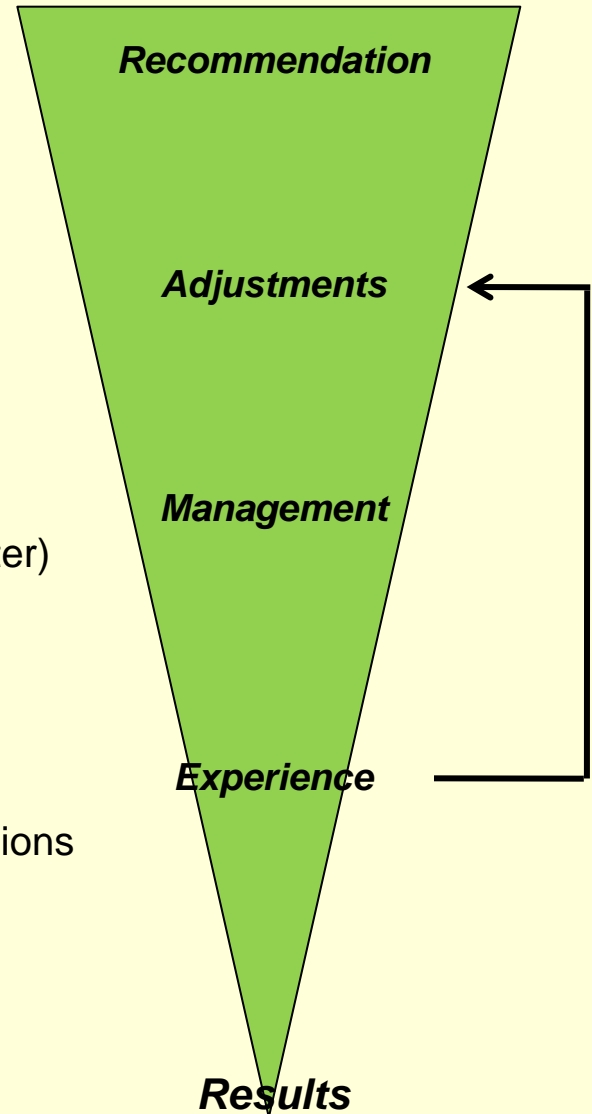
It's Tough!

- Very complex
- Very leaky
- Dependent on weather
- We understand N behavior but it is very difficult to predict usefully
- ***N Recommendations are a process.....not the final answer***



N Management Process

- **Recommendations**
 - Crude, but hopefully educated guesses
 - Get us started in the ballpark
- **Adjustments**
 - Rough estimates
 - Soil N supply
 - Legumes
 - Manure
 - Refine the guesses
 - Use tools (CSNT, PSNT, ISNT, Chlorophyll Meter)
- **Management**
 - Fertilizer efficiency
 - Source, method and timing of application
- **Experience**
 - N management is a series of successive approximations
 - Corn Stalk Nitrate Test
 - Check strips
 - Records



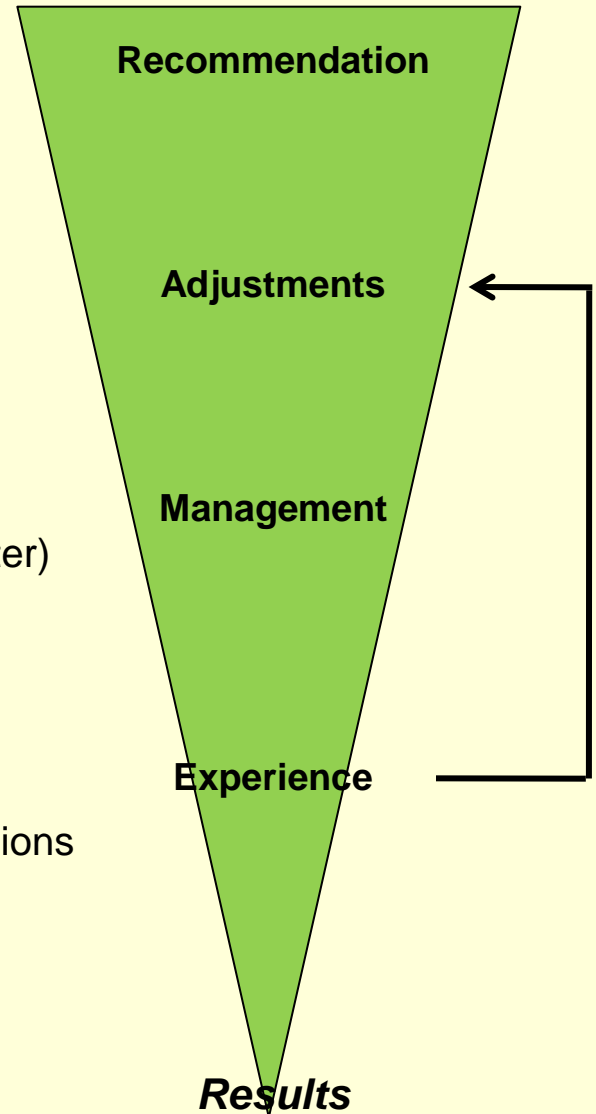


Nitrogen Recommendations

- N recommendations are based on expected yield, sometimes include soil type and history
 - Ex. Corn 1.0 lb N/bu expected yield, past manure credits, sod or soybean credits
- Recommendations are ranges reflecting uncertainty and changing economics
 - Ex. 10:1 corn:N price ratio (\$7 Corn: \$0.70 N), expressed as ranged 100-120 lbs N/acre, lower range with high N price, etc.
- Recommendations already have a safety buffer built in
 - Don't exceed recommended rates
- **N recommendations are not the final answer**

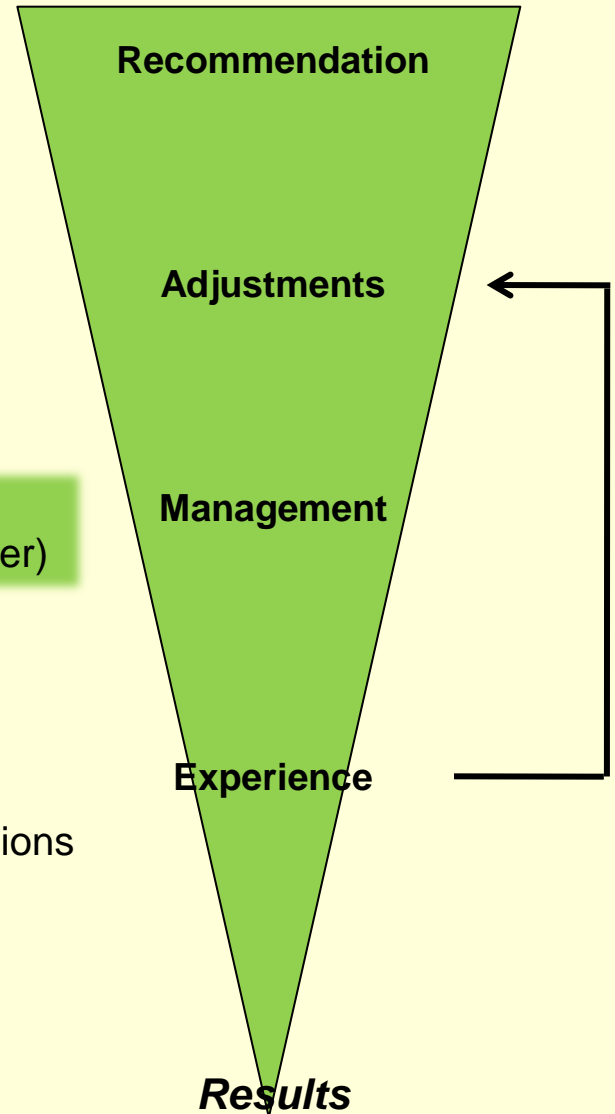
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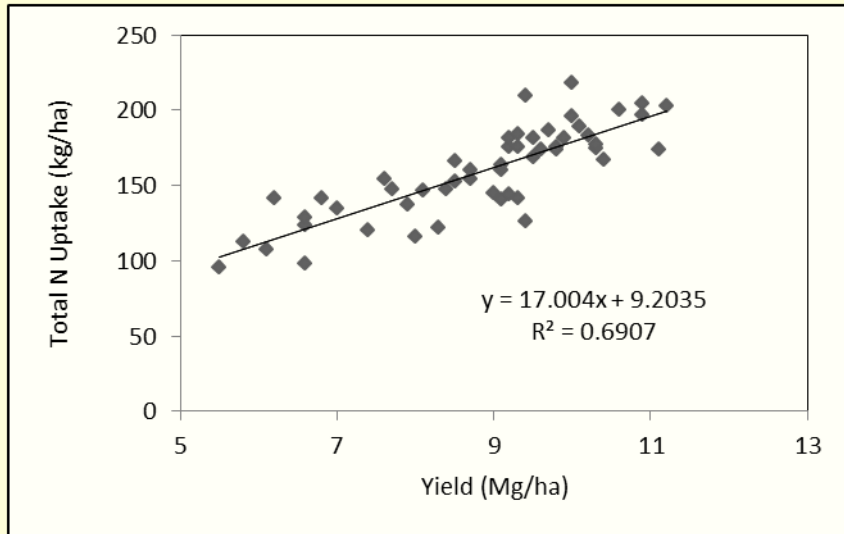
Tools for Adjusting N Management

- High producing soils often need the least external (fertilizer) N
 - Why?
 - Where is this N coming from?

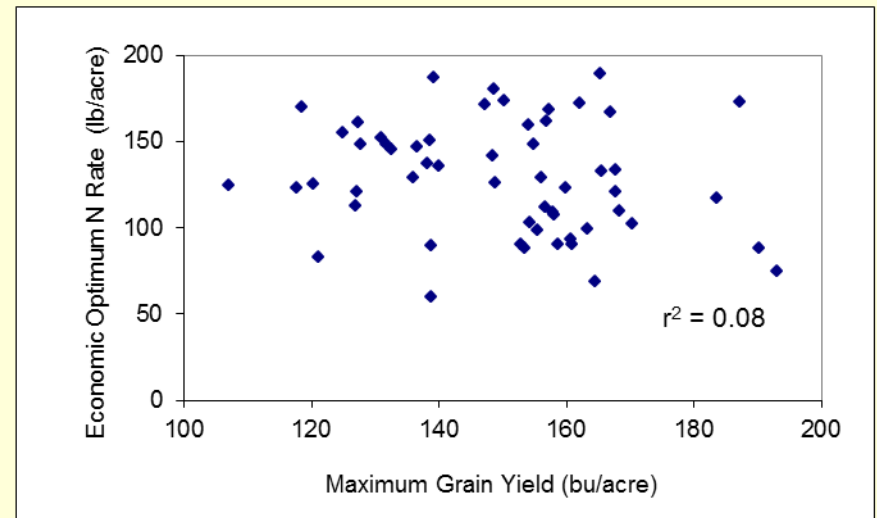


Yield Goal Based N Recommendations

Fox, PSU



~SOIL N~



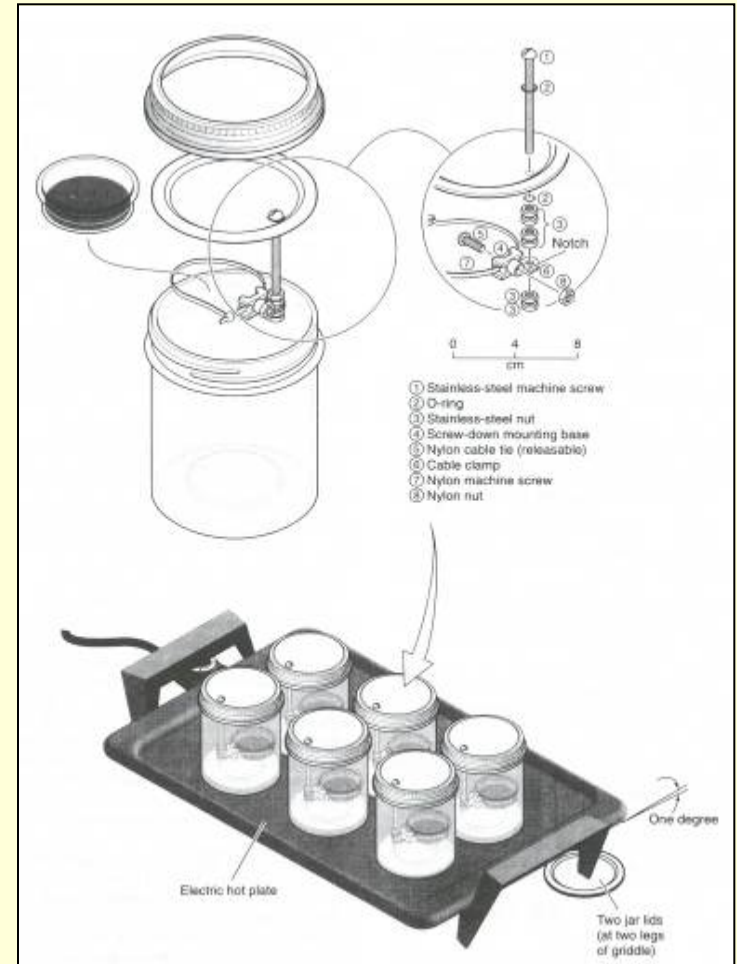
New York Recommendation Example

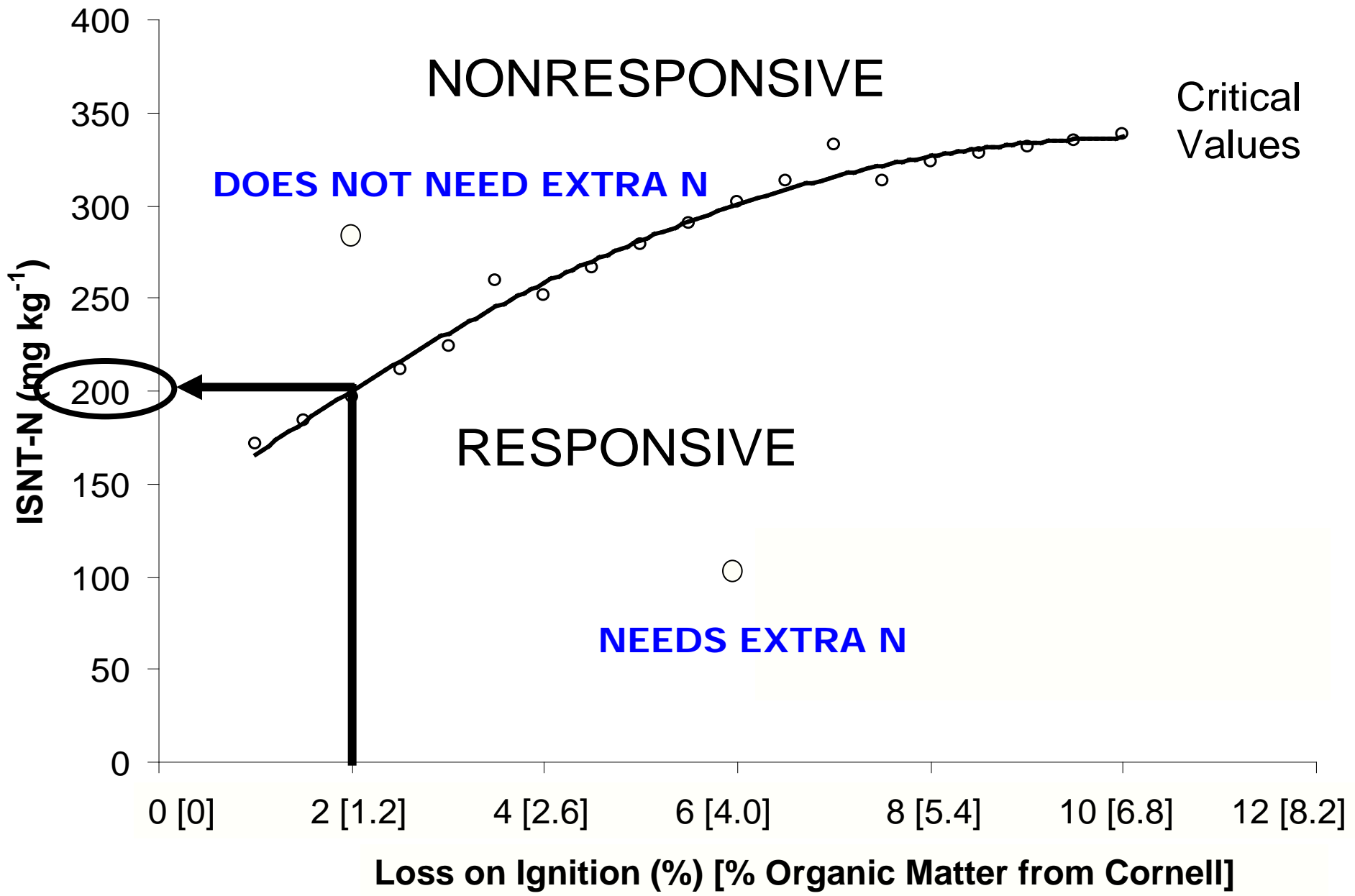
$$\text{N req.} = \frac{
 \begin{array}{l}
 \text{in bushels/acre} \\
 \text{(yield potential * 1.2)} - \text{soil N} - \text{sod N} \\
 \text{in lbs N/acre}
 \end{array}
 }{
 \begin{array}{l}
 \text{(fertilizer efficiency/100)} \\
 \text{in \%}
 \end{array}
 }$$

in lbs N/acre (pointing to N req.)
 in lbs N/acre (pointing to soil N)
 in % (pointing to fertilizer efficiency/100)

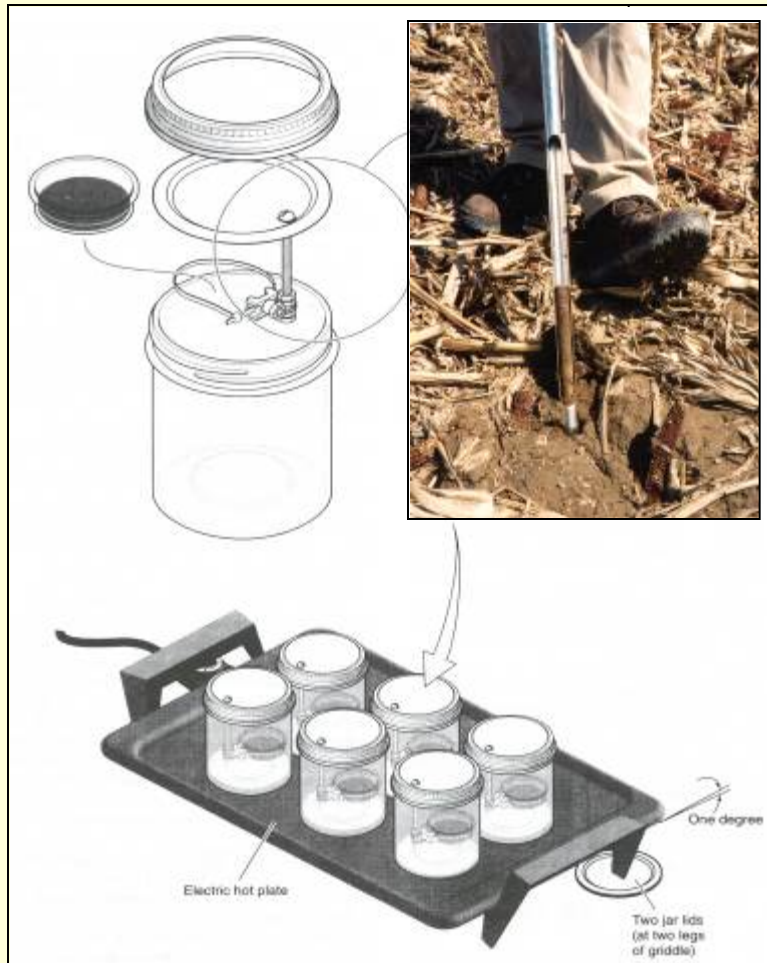
Tools for Adjusting N Management

- On-the-ground improvements in N use for corn will depend on:
 - Our ability to predict soil N supply
 - Availability of practical assessment tools
 - Soil nitrate testing
 - Soil organic matter testing
 - Illinois Soil Nitrogen Test





Tools for Adjusting N Management



ISNT and
CSNT

A
package
deal
worth
testing!

Corn Stalk Nitrate Test

New York Field Calibrations:

Low:

= less than 250 ppm N

Marginal:

= 250 to 750 ppm

Optimal:

= 750 to 2000 ppm N

Excess:

= more than 2000 ppm N



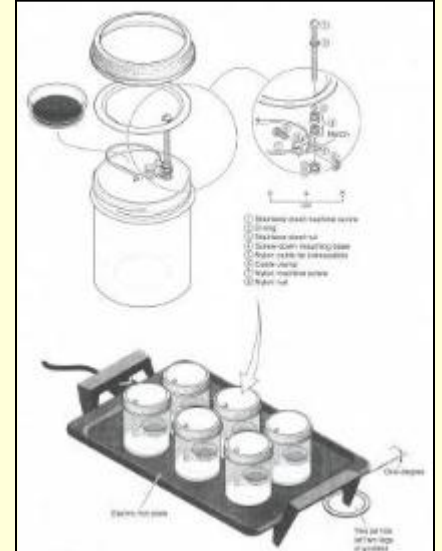
Tools for Adjusting N Management

Adaptive Management for Corn using CSNT and ISNT

Action 1: Take CSNT and ISNT of 2nd year corn fields

- If $750 < \text{CSNT} < 2000$ ppm, no changes next year
- If $\text{CSNT} < 250$ ppm, and plants looked N deficient, evaluate the need for additional N (take weather into account to explain why $\text{CSNT} < 250$ ppm)
- If CSNT between 250 and 750 ppm, and plants look N deficient, evaluate the need for additional N (take weather into account $\text{CSNT} < 750$ ppm)
- If $\text{CSNT} > 2000$ ppm, more N than needed
 - If ISNT also sufficient, eliminate sidedress N
 - If ISNT is deficient or marginal, reduce rates but don't eliminate

Action 2: Retest CSNT next year to evaluate again

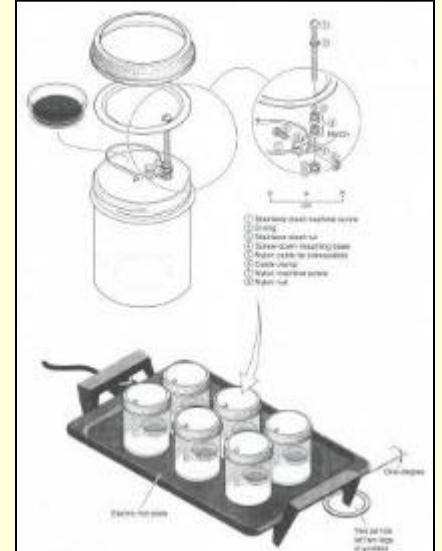


Tools for Adjusting N Management

Adaptive management for corn using CSNT and ISNT as a package

Greatest benefits of this approach:

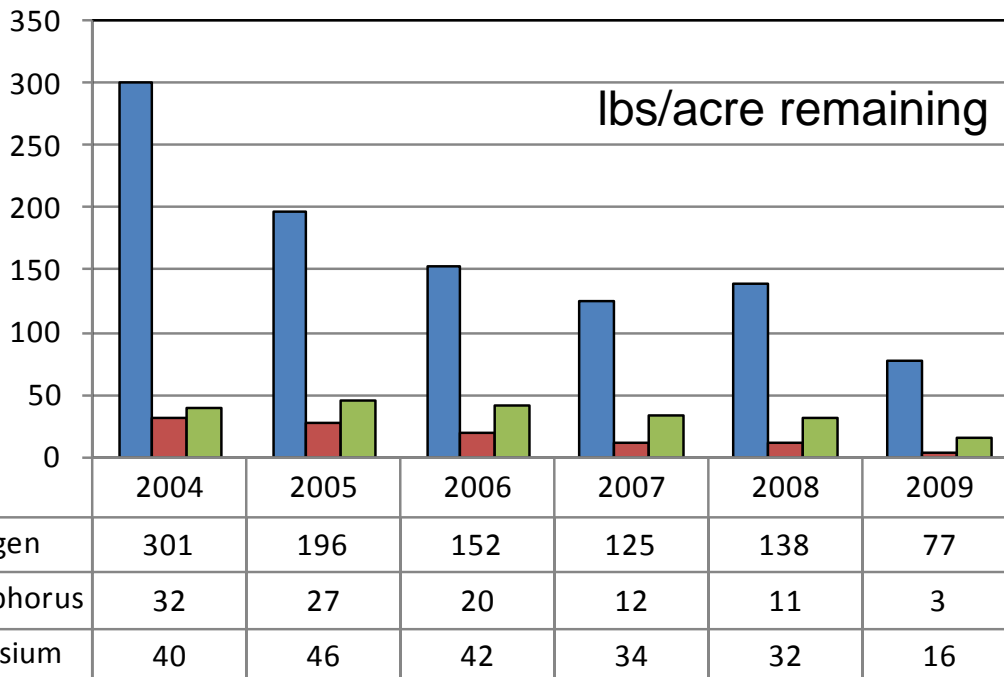
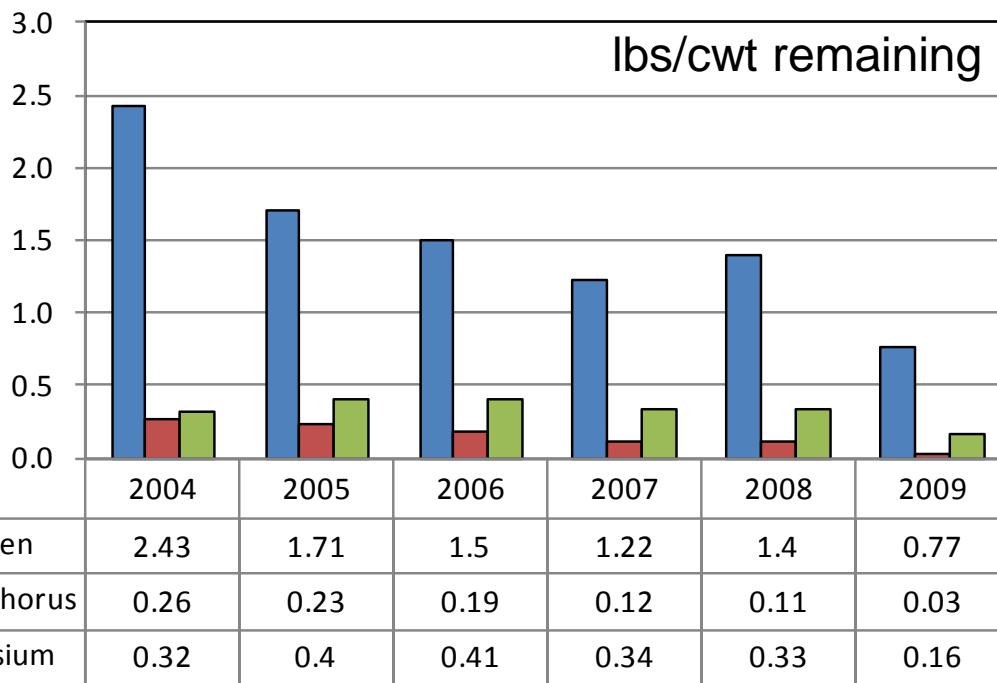
- Decisions can be made in the fall
- Applicable for non-sidedressed situations
- Allows for adjustments; field by field basis
- Allows for selection of fields where return to N fertilizer is the greatest
- Enables farm to better balance whole farm N use
- ISNT can be added to regular soil samples (0-8 inch depth)



Monitor
improvements
at the farm
level!!

Simple
assessment

Software/help
available



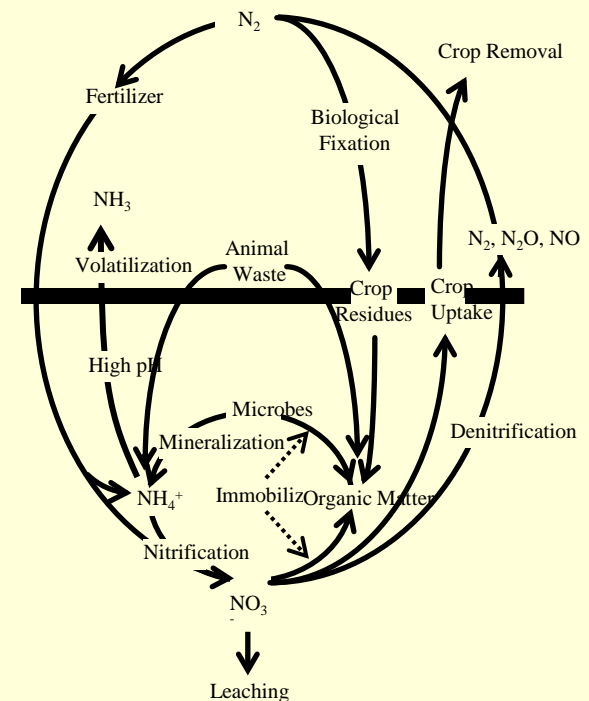
Pre-Plant Soil Nitrate Test

- **Humid regions**

- Pre-plant nitrate testing more difficult because dynamic nature of N – can change dramatically between testing and crop uptake
- Can be useful under specific conditions

- **Dry regions**

- With low rainfall, loss of nitrate is lower
- Measured root zone nitrate-N can be used to adjust N recommendations



Pre-Plant Soil Nitrate Test

- Humid regions

- Pre-Plant Nitrate Test (PPNT) – (Bundy, Wis.)

- Conditions for use:

- Carryover N

- Corn after corn

- Medium to fine textured soils

- Normal or below normal rainfall

- Does not assess organic N sources

- Sample in early spring

- Sample to 2 ft. depth in 1 ft. increments

- Dry or freeze samples

- Test for Nitrate-N

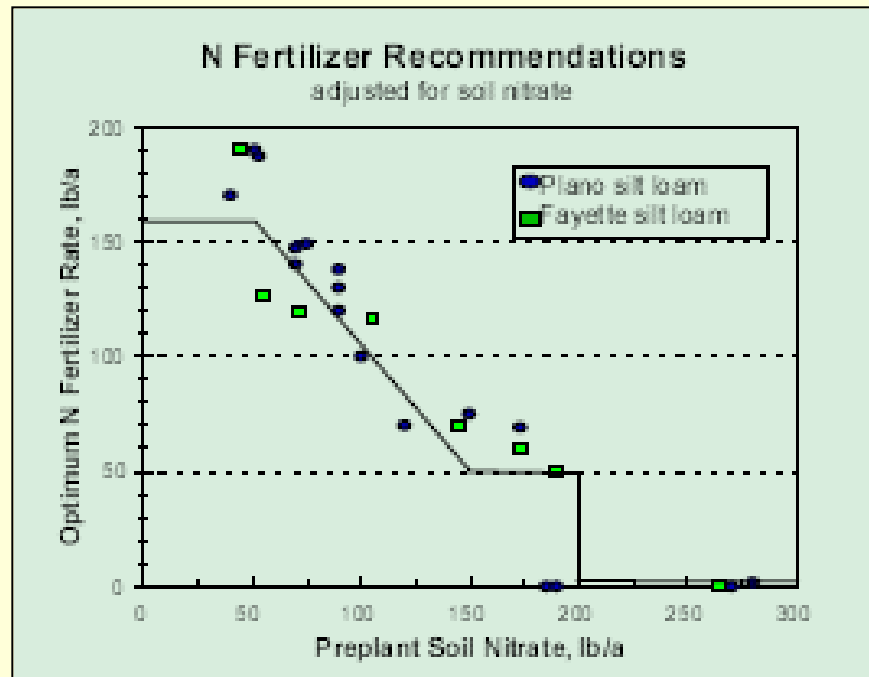
Pre-Plant Soil Nitrate Test

- Humid regions

- Pre-Plant Nitrate Test (PPNT) – (Bundy, Wis.)

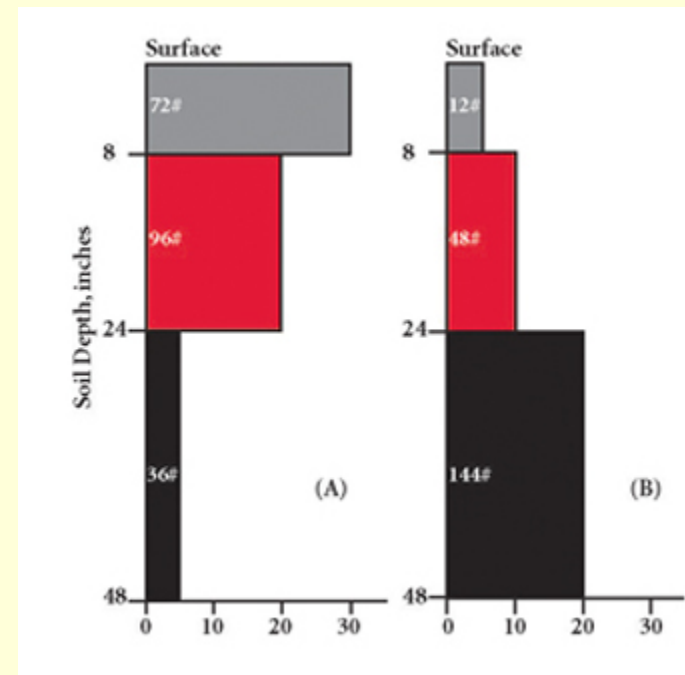
- Recommendations:

- Soil nitrate 0-200 lb/A: Rec. N= Std. N - (Soil Test N - 50)
- Soil nitrate >200 lb/A: No N recommended



Pre-Plant Soil Nitrate Test

- **Dry regions**
 - Follow state guidelines
 - Sample in the spring if possible
 - If sampled in the fall and high rain fall occurs, resample in the spring especially on coarse texture soils
 - Sample to 2-4 ft.
 - Sampling in depth increments can provide additional information
 - Dry or freeze samples
 - Test for Nitrate-N

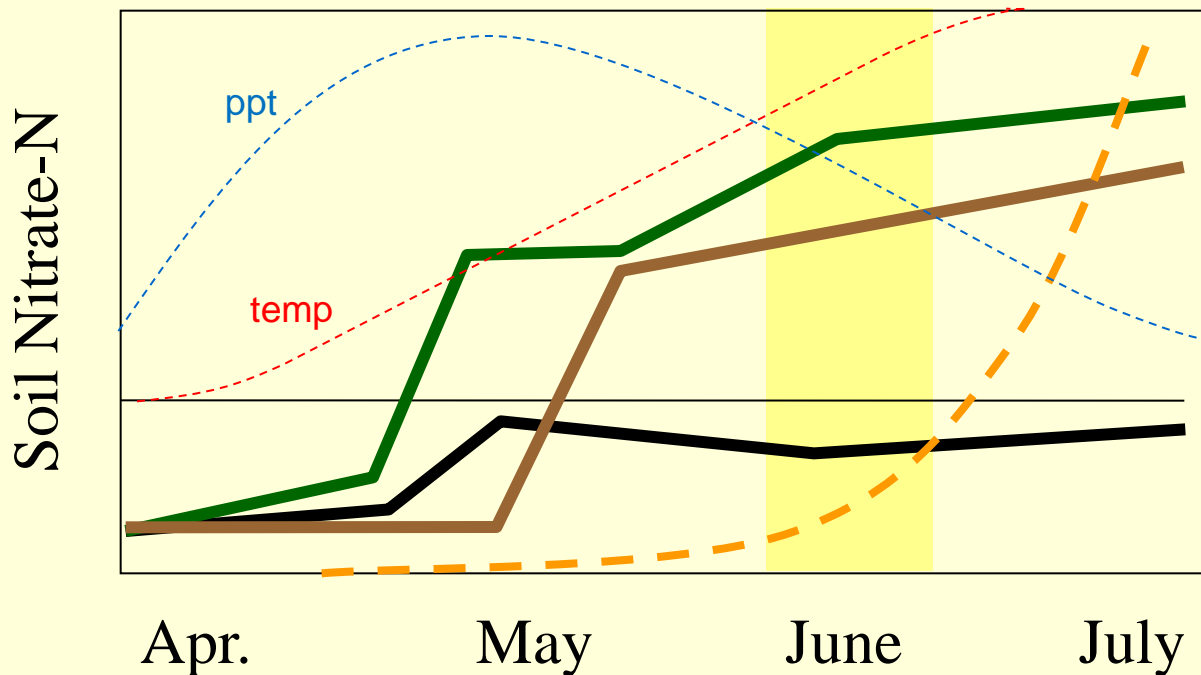


Pre-Plant Soil Nitrate Test

- **Dry regions**
 - Recommendations: Follow state guidelines
 - Generally measured nitrate-N in the sampled depth is subtracted from the base recommendation
 - Example:
Base recommendation – (Sample depth in ft. X ppm NO₃-N X 4)
 - Separate credits for manure and legumes also part of the recommendation

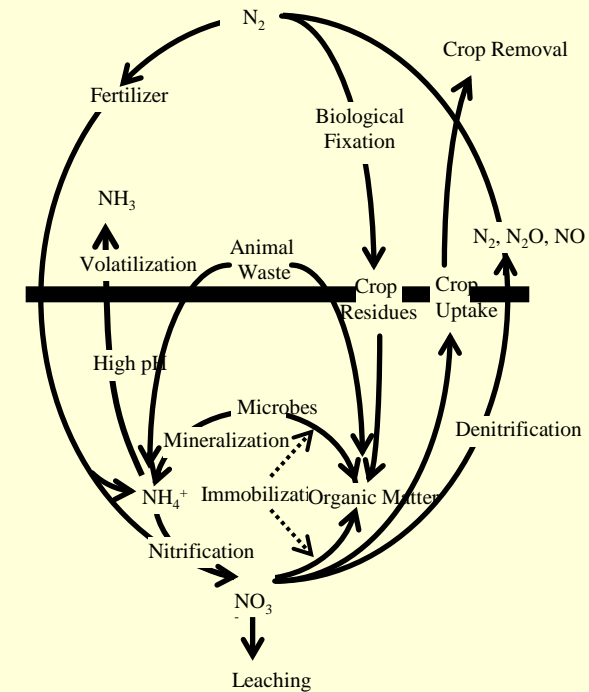
In-season Soil Nitrate N Testing

- Especially helpful with organic sources of N



— Control
— Alfalfa

— Manure
- - - N Uptake by Corn



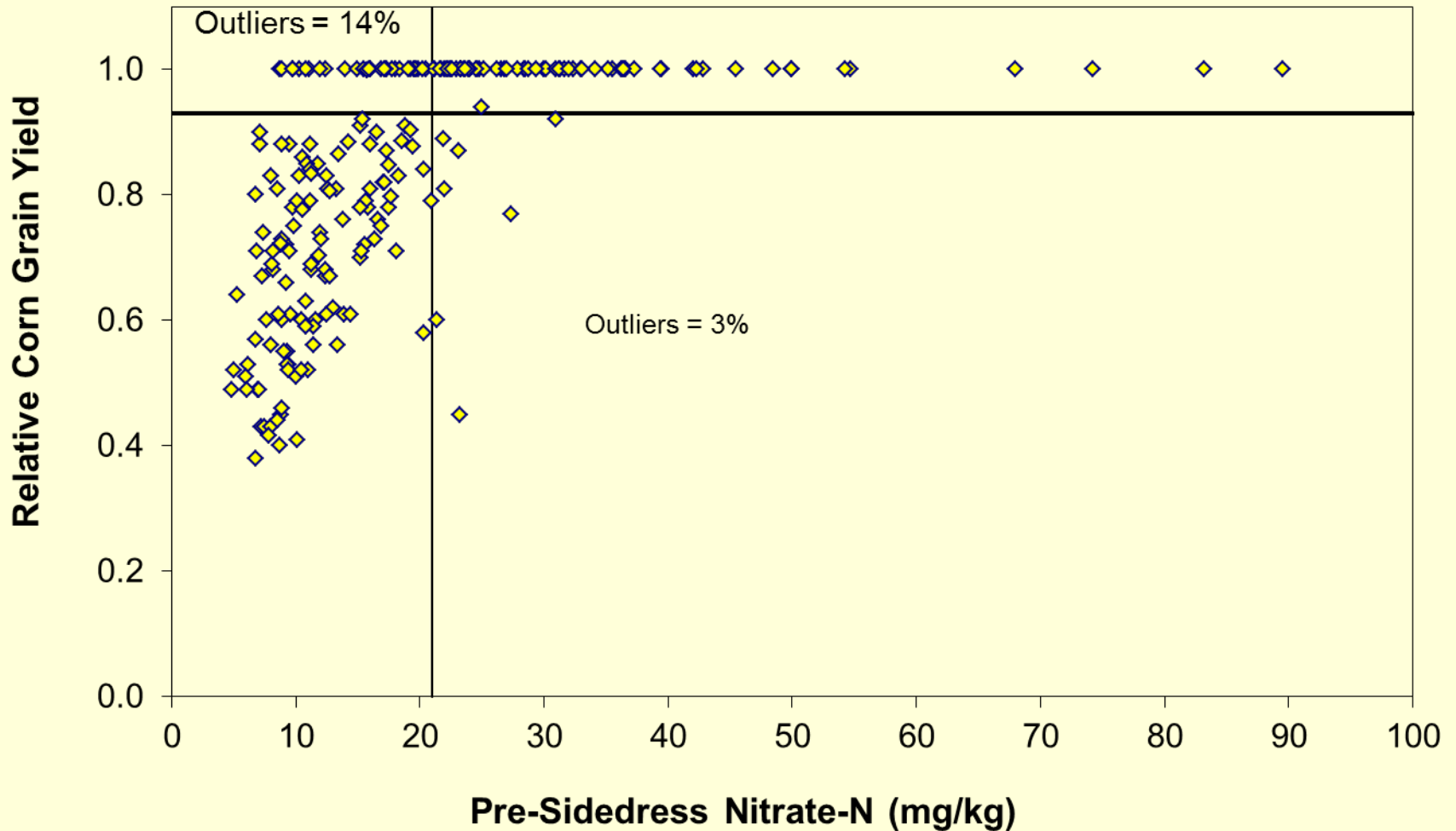
Pre-sidedress Soil Nitrate Test for Corn

Procedure

- Minimal N at planting
- Sample when corn is ~12 in. tall
- Take 12 in. deep soil samples
- Dry immediately
- Test for nitrate
- > 20-25 ppm No N
- < 20-25 Calculate sidedress N recommendation



Presidedress Soil Nitrate Test



Pre-sidedress Soil Nitrate Test for Corn

- Mainly used for corn & some vegetables
 - See state guidelines for corn
 - PSNT for Vegetables, J. Heckman, Rutgers

http://njveg.rutgers.edu/assets/pdfs/soil/e285-jhSoil%20Nitrate_Testing_as_Guide_to_Nitrogen_Management_for_Vegetable.pdf

- Most useful in systems with organic sources of N
- **Excellent indicator of adequate N**
- Reduces insurance fertilization
- Improved N recommendations
 - In Pa, PSNT recs twice as accurate as no PSNT
- Requires delayed application of N

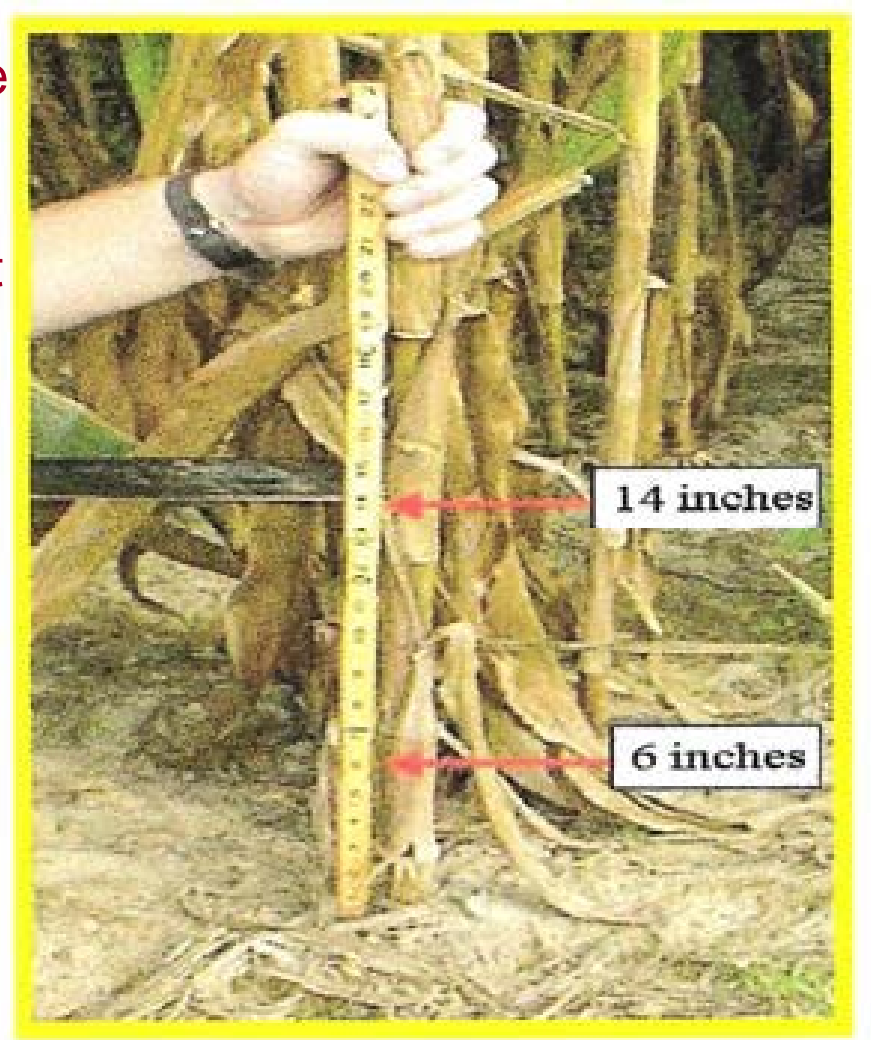
Corn Stalk Nitrate Testing

Tom Morris, University of Connecticut

Corn Stalk Nitrate Test

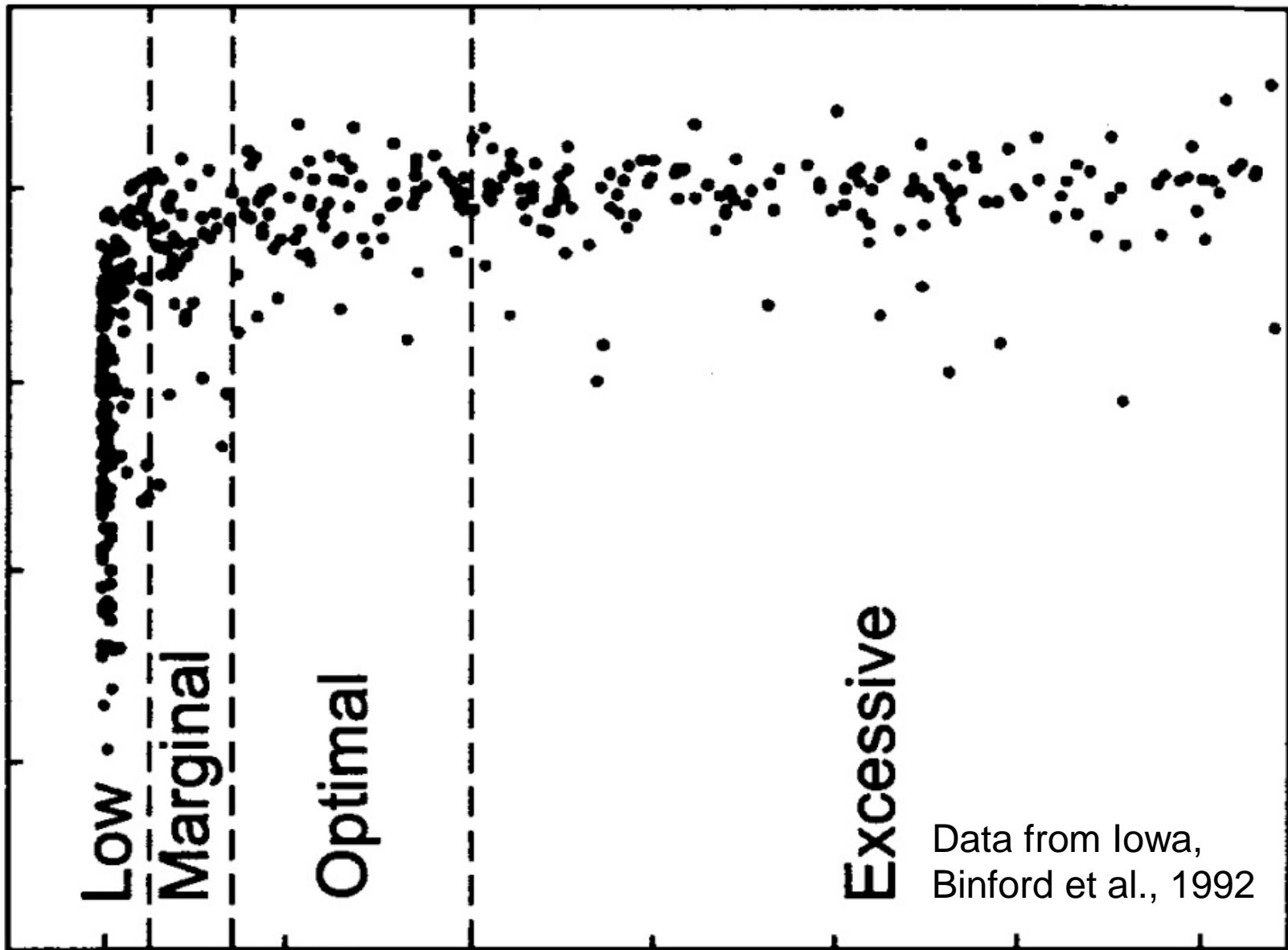
Cut stalk at 6 and 14 inches above the ground

Cut from 1-week before silage harvest to 3 weeks after black layer



Relative Yields of Corn (%)

100
75
50
25
0



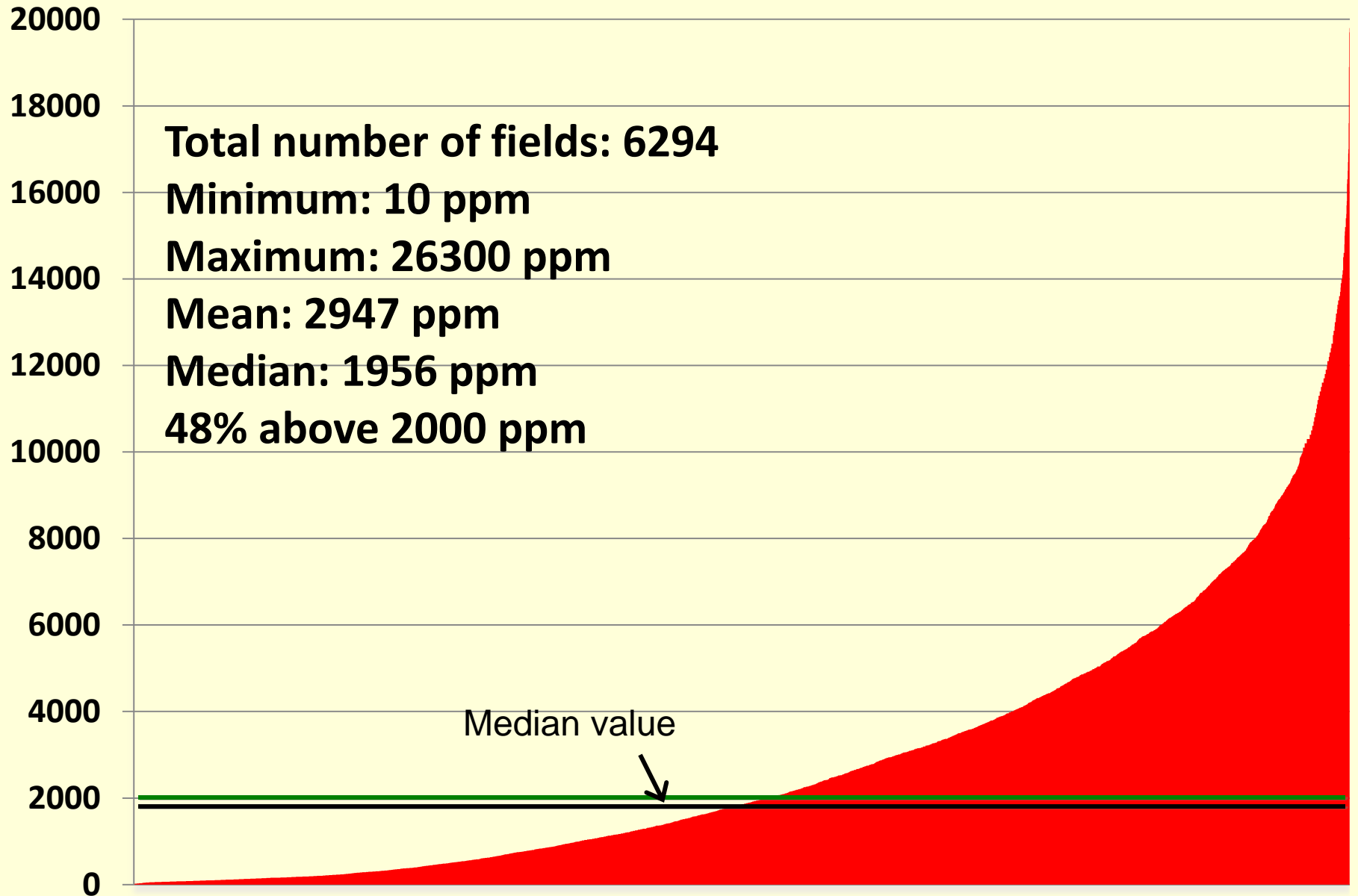
Data from Iowa,
Binford et al., 1992

Nitrate-N Concentration in Stalk (ppm)

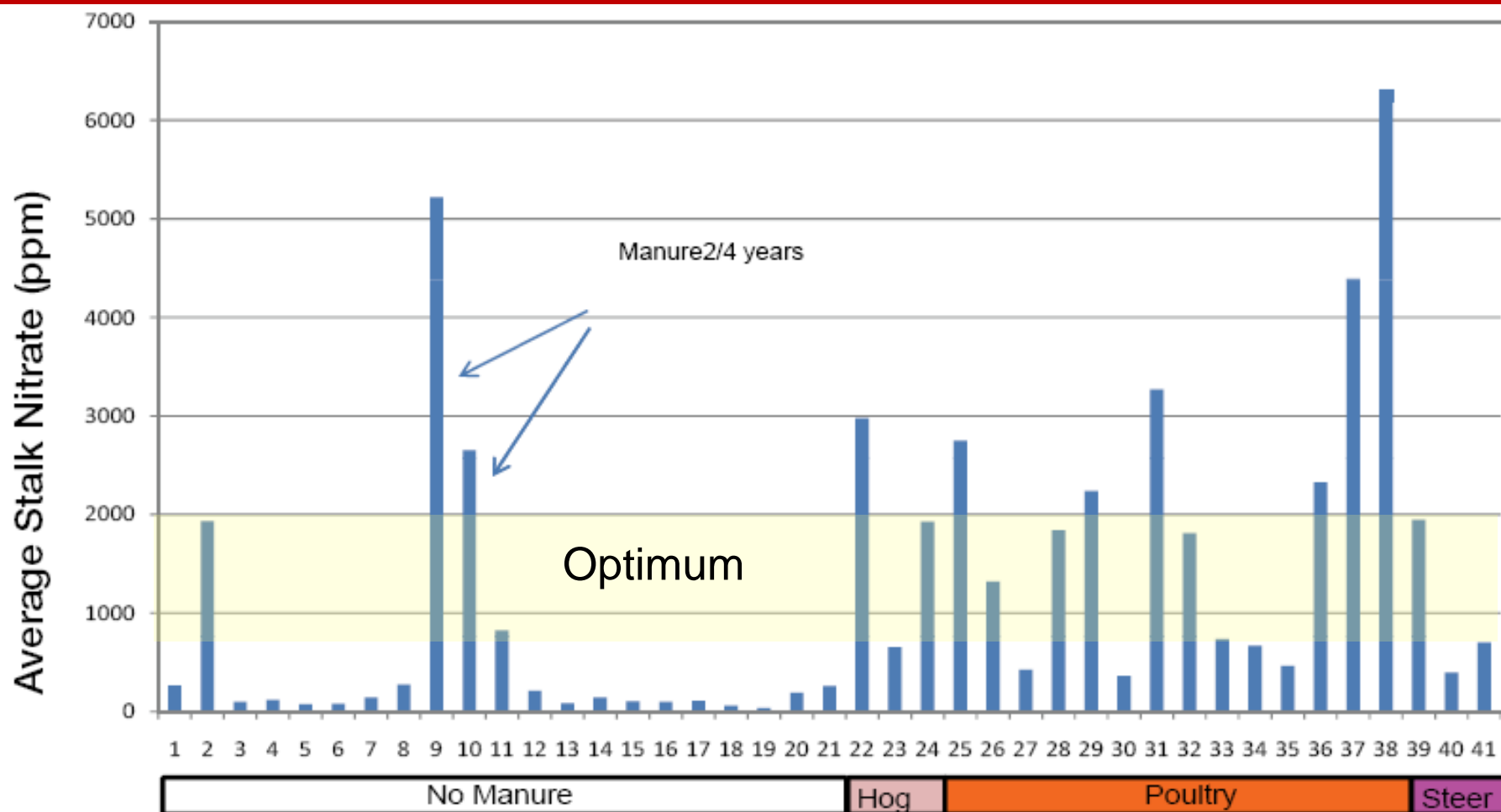


CORNSTALK NITRATE-N (NO_3^-)
mg kg⁻¹ (ppm)

Corn Stalk Nitrate Concentrations 2004-2011



41 fields at one farm in one year – Tells farmer where needs to improve N management



Major differences:

- 1) Fields that received different types of manure tested higher than those that received only commercial fertilizer.
- 2) The test is sensitive to detect fields with a manure history.
- 3) Large variability in stalk values for fields that received poultry manure.

Use of Corn Stalk Nitrate Test Results

University of Connecticut

Manured fields

If CSNT > 2000 ppm for two years, reduce manure rate by half; Use Pre-sidedress soil nitrate test to check if sufficient nitrogen

If CSNT between 700 and 2000 ppm, no change

If CSNT between 250 and 700, and plants not N deficient, no change; if N deficient, evaluate N management

If CSNT < 250 ppm and plants not N deficient, no change; if N deficient, evaluate N management

Effect of Height of Cut on CSNT Results

Concentration of nitrate in corn stalk increases as move down stalk

Important to cut stalk at 6 and 14 inches above ground

Recent research at Cornell shows:

Results within 5% of value of stalks cut at 6 and 14 inches can be obtained by:

- sampling 7-inch stalks between 6 and 13 inches above ground
- sampling 6-inch stalks between 7 and 13 inches above the ground

If no rain on cut stalks, can sample stalks up to 5 days after silage harvest – Cornell data

Table 3. Effect of delaying 0, 1, 2, or 5 days after harvest in taking samples for the corn stalk nitrate test, across 4 replications (n=4).

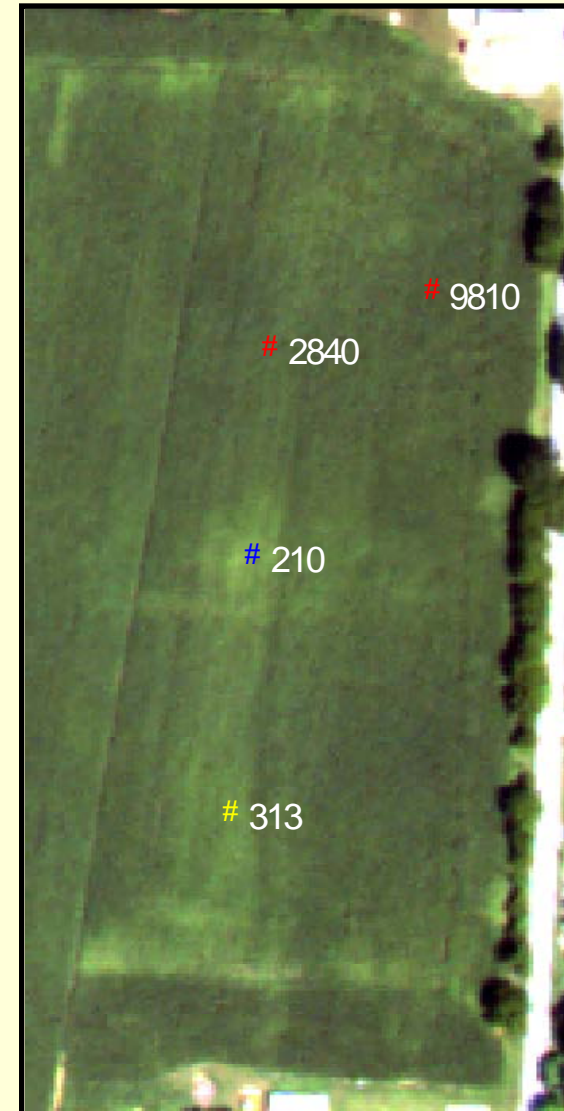
Treatment	Corn stalk nitrate test	
days	----- mg NO ₃ -N kg ⁻¹ -----	
0	11,686	a
1	11,092	a
2	11,709	a
5	11,858	a
Treatment	<i>P</i> =0.1408	Hong, et al., in review

Guided Stalk Samples

Corn Stalk Samples Collected Based on Aerial Images

Process

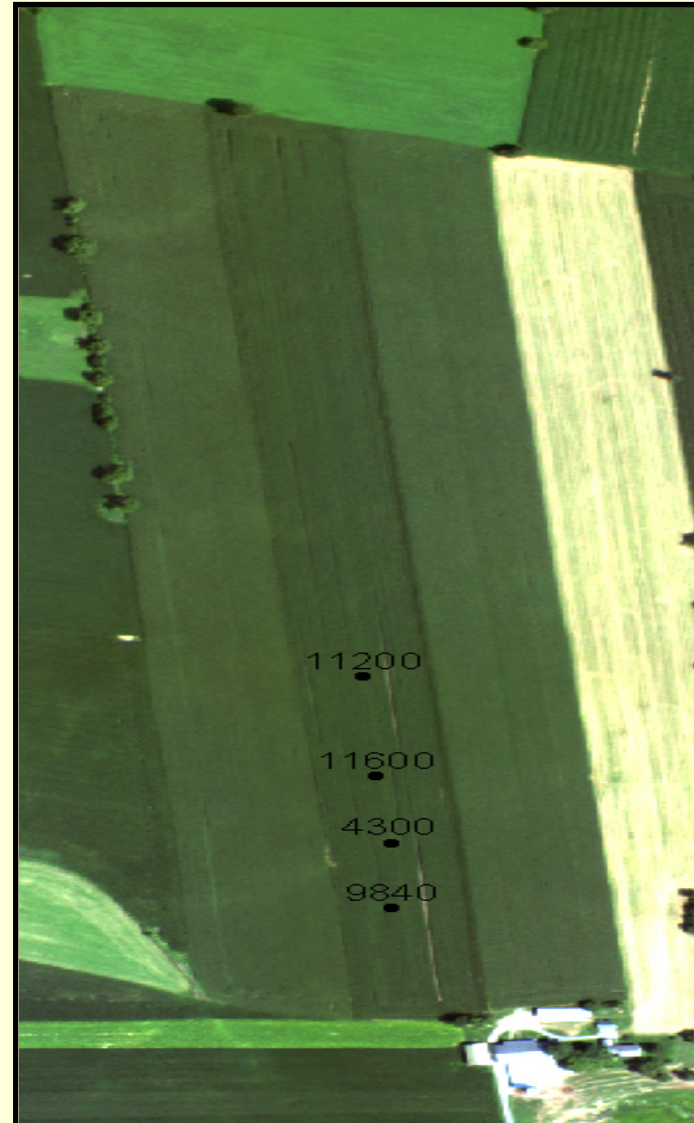
- Aerial image of field collected shortly after tasseling
- Four locations chosen in each field based on soil type and or greenness
- Use hand-held GPS to find locations
- Collect 10 stalks from 2-row by 40-foot area at each location



Guided Stalk Samples

Advantages Compared with Random Sampling

- Provide confidence in CSNT results
- Information about spacial variation of nitrogen in field
- Better information about overall nitrogen status of field
- Information to improve application of nitrogen and other machinery-controlled management such as seeding, herbicide applications





343

4680

4280

2060



143
#

369
#

194
#

214
#

287
#

360
#

207

Soil Testing for Phosphorus

Traditionally soil testing completed every 3-4 years

Main use of soil test reports has been for lime and fertilizer application rates

On farms with surplus phosphorus, and many high testing fields, testing every other year or every year to track soil test phosphorus concentrations by field is an important use of soil testing

Plant Sampling and Analysis

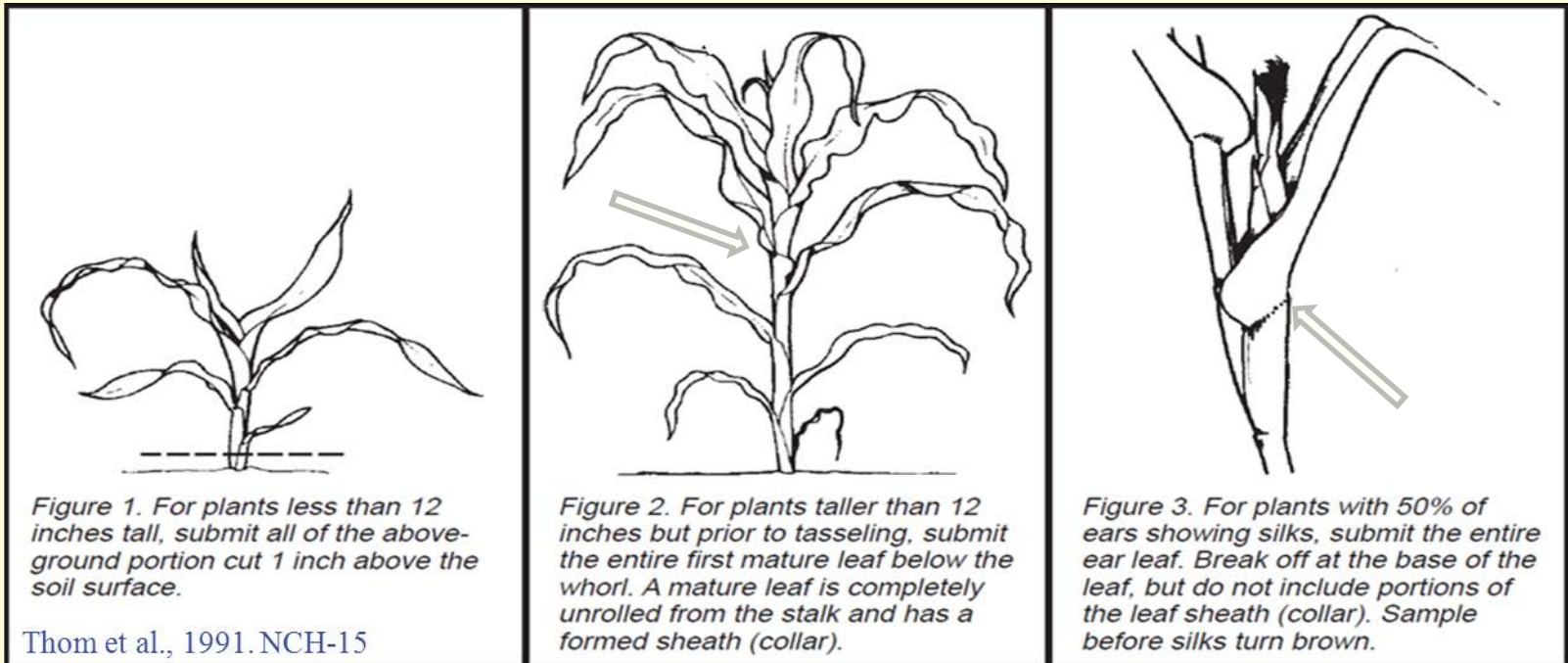
Jim Camberato, Purdue University

Plant Sampling and Analysis

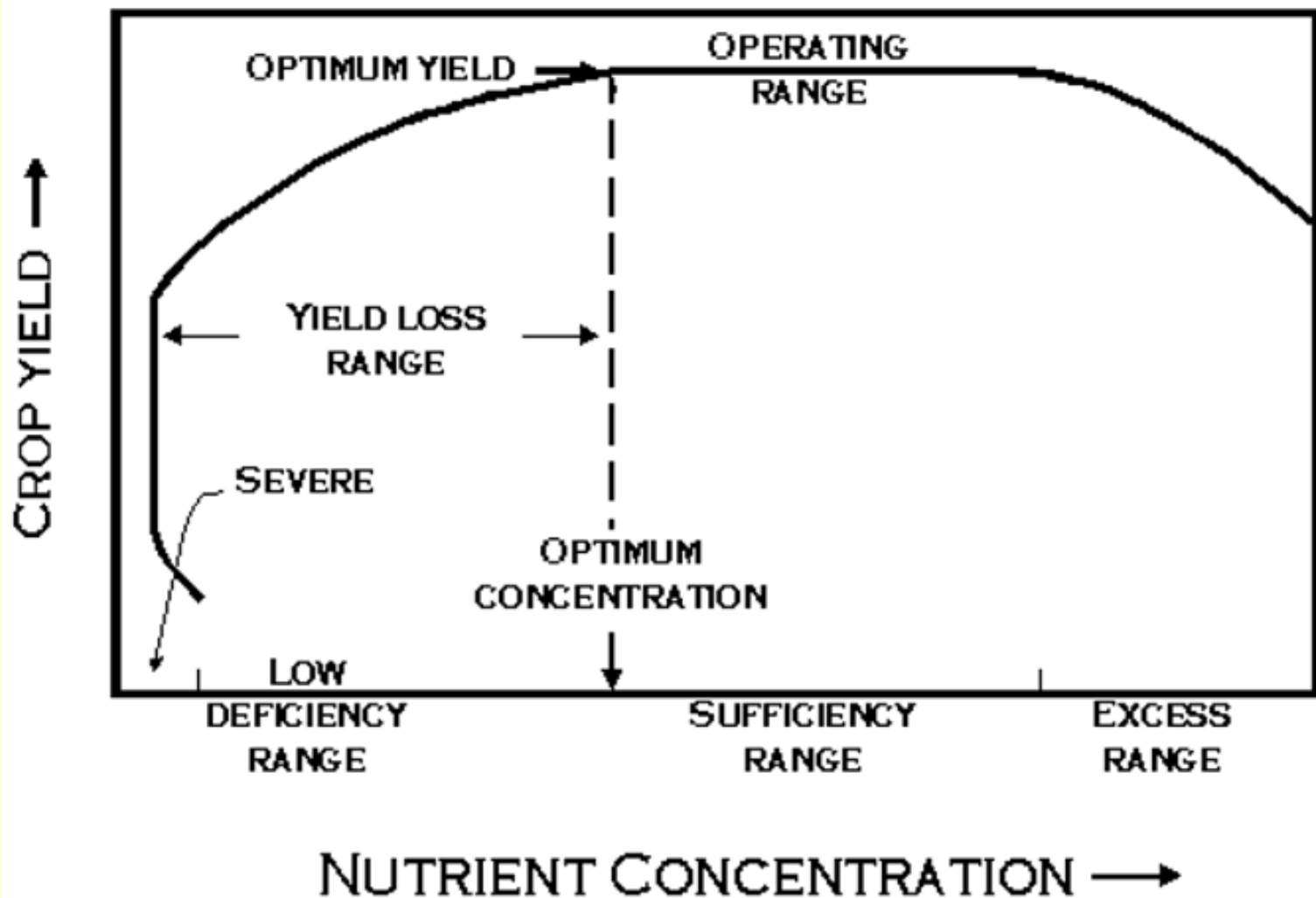
- Traditionally used to monitor crop nutrient status particularly for nutrients not assessed well by soil testing, such as N, S, B, Mo (adaptive over the long term)
- Troubleshooting poor crop growth
- Recently being marketed for in-season management with exceptionally high critical values (without publicly available data to support its use)

Sampling Corn

- Entire plant at young stages
- Most recently collared leaf until silking
- Earleaf during reproductive growth



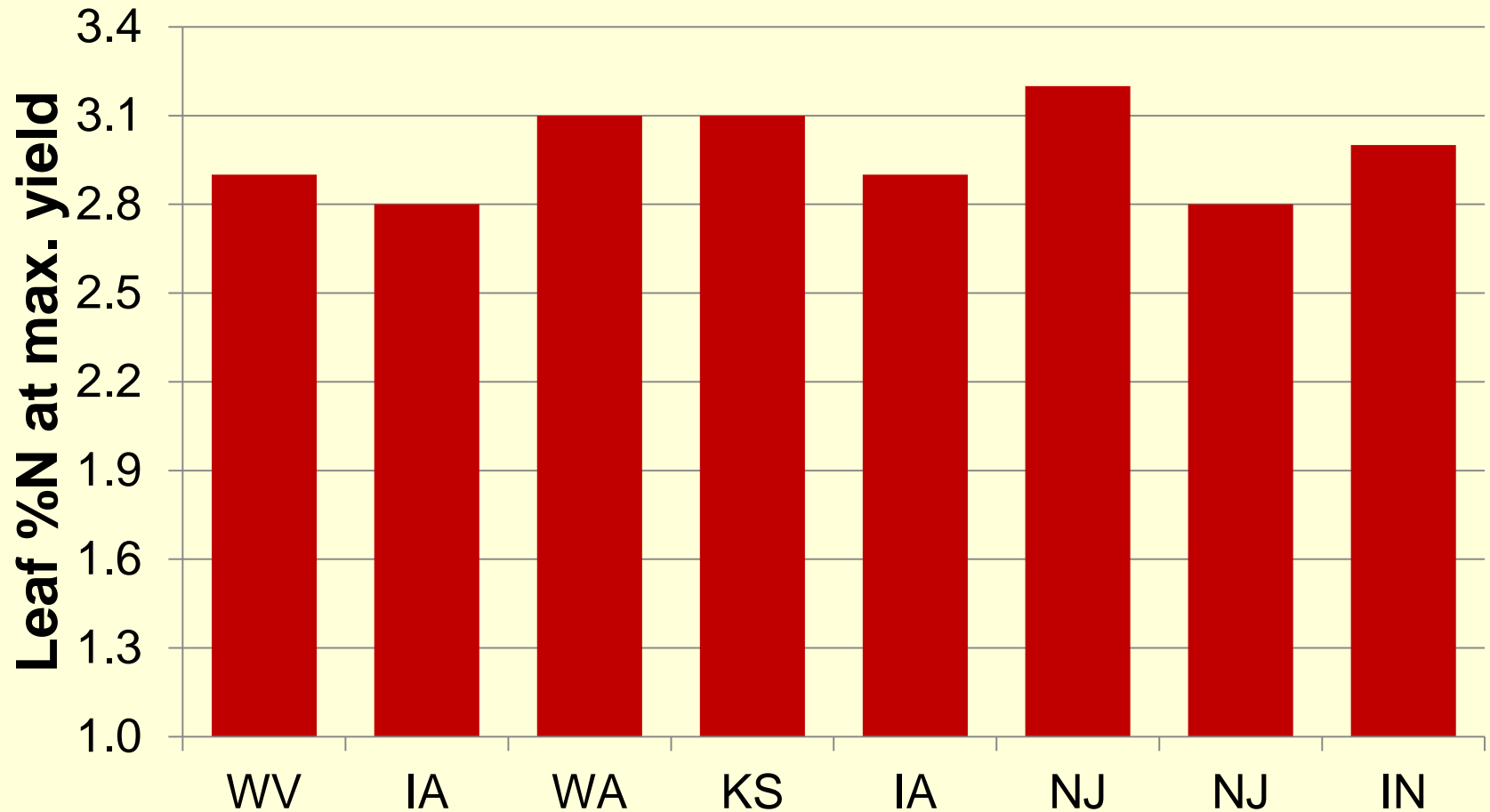
Sufficiency Ranges



Nutrient	<4" plt.	4" to tassel (leaf)	Tassel to bloom (leaf)	Maturity
N, %	4.0 – 5.0	3.0 – 4.0	2.8 – 4.0	2.5 – 3.5
P, %	0.4 – 0.6	0.3 – 0.5	0.25 – 0.5	0.25 – 0.4
K, %	3.0 – 4.0	2.0 – 3.0	1.8 – 3.0	1.6 – 2.5
Ca, %	0.3 – 0.8	0.25 – 0.8		0.2 – 0.8
Mg, %	0.2 – 0.6	0.15 – 0.6		0.12 – 0.5
S, %	0.18 – 0.50	0.15 – 0.4	0.15 – 0.6	0.12 – 0.4
Fe, ppm	40 – 250	30 - 250		
Mn, ppn	25 – 160	20 – 150	15 – 150	
Zn, ppm	20 – 60	20 – 70		16 - 50
Cu, ppm	6 – 20	5 – 25		4 - 20
B, ppm	5 – 25			3 – 20
Mo, ppm	0.1 – 2.0			

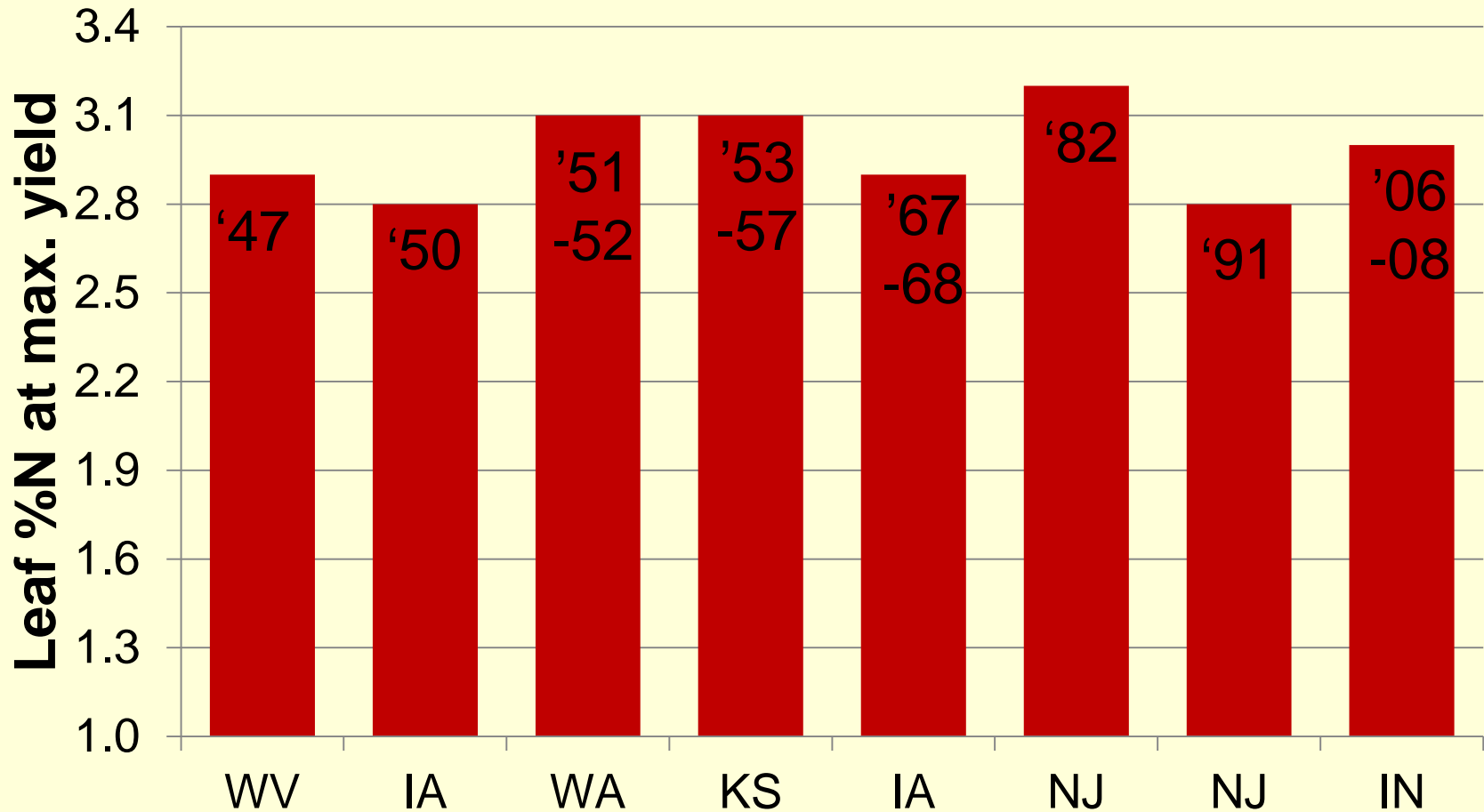
Ear leaf %N assoc. with max. yield

2.8-3.2% across diverse growing environments



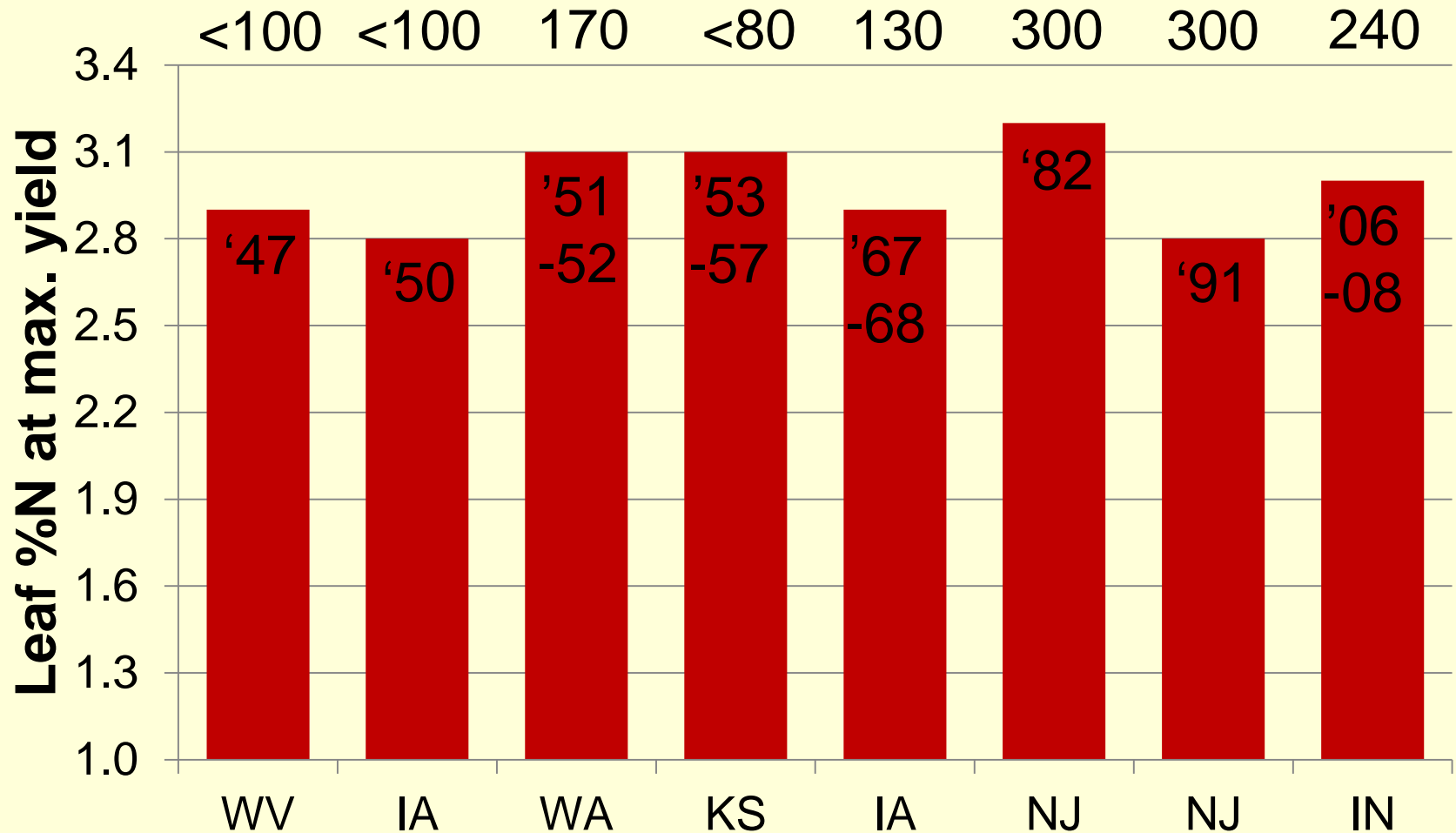
Ear leaf %N assoc. with max. yield

2.8-3.2% across seven decades



Ear leaf %N assoc. with max. yield

Maximum yield, bu/acre



Ear leaf nutrients - 300 bu/a corn

	N	P	K	Ca	Mg	S	B	Cu	Mn	Zn
	----- % -----					----- ppm -----				
NJ-1991	2.8	0.29	2.3	0.48	0.20	0.22	8	9	31	23
NJ-1982	3.2	0.40	2.3	0.51	0.17	0.20	14	11	43	39
Sufficiency ranges	2.8-4.0	0.25-0.5	1.8-3.0	0.25-0.8	0.15-0.4	0.15-0.6	5-25	5-25	15-150	20-70

Plant tissue does not have to be in the high end of the sufficiency range to make high yields

Plant Sampling and Analysis

- Typically used as a long-term assessment tool
- In-season utilization requires a robust database (and perhaps a reference strip approach)



Crop sensors & chlorophyll meters

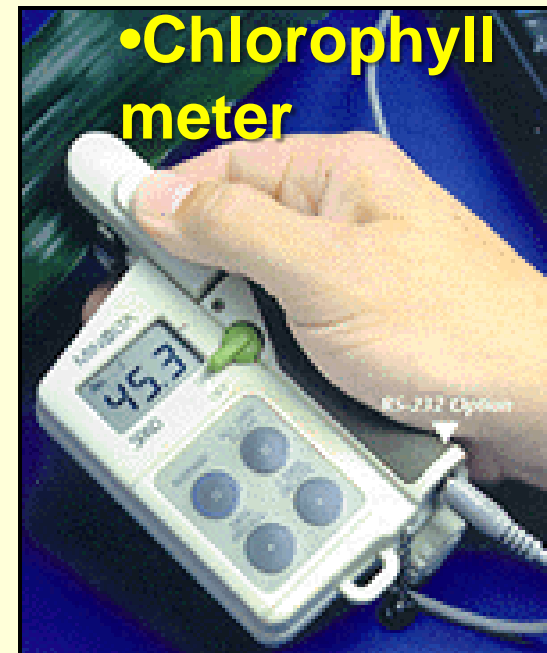
Peter Scharf
University of Missouri

Crop sensors & chlorophyll meters

- **Concept: Crop color reflects soil N supply**
- **Dark green = N sufficient, high N availability, low N fertilizer need**
- **Light green or yellow-green = N deficient, low N availability, high N fertilizer need**

Crop sensors & chlorophyll meter

- Sensors measure reflectance
- Chlorophyll meter measures transmittance
- Both are sensitive to pigment concentrations in leaves, which are sensitive to N status

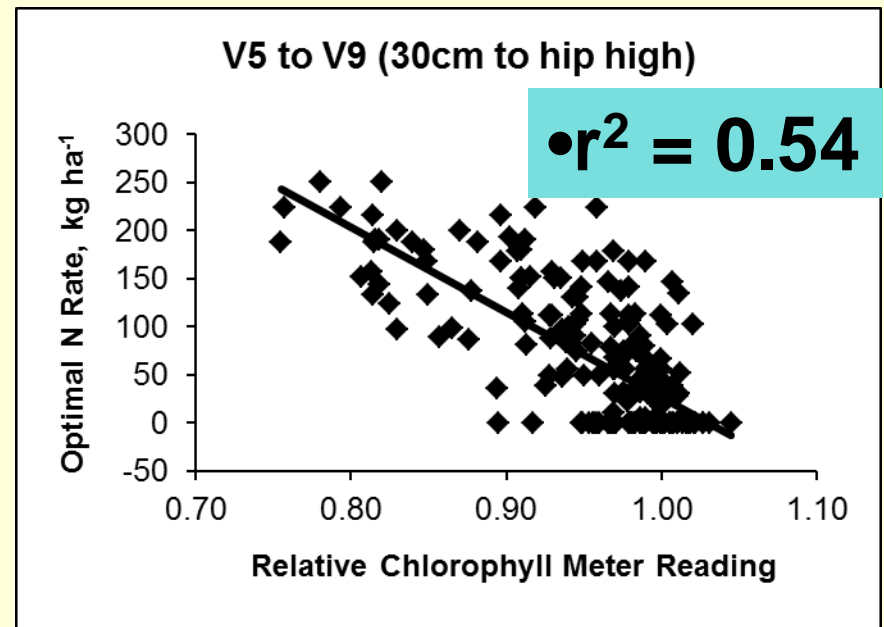
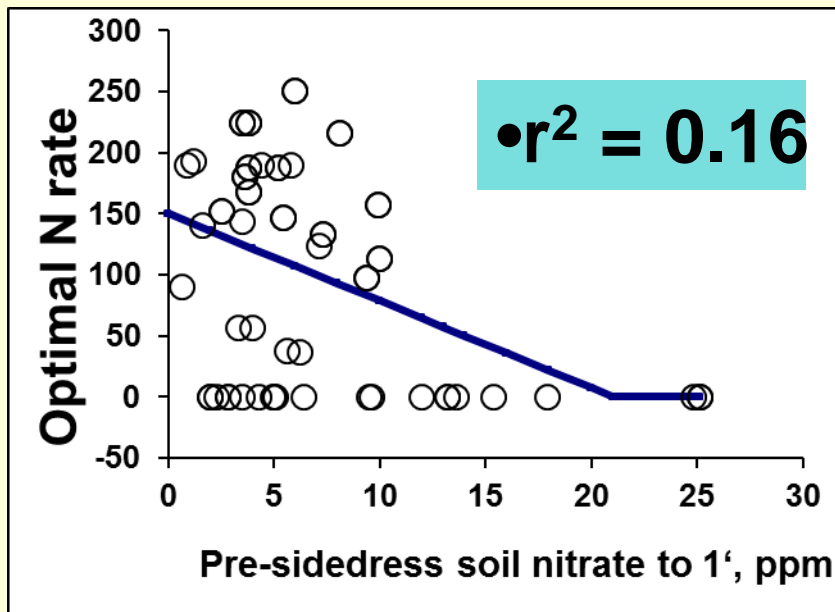
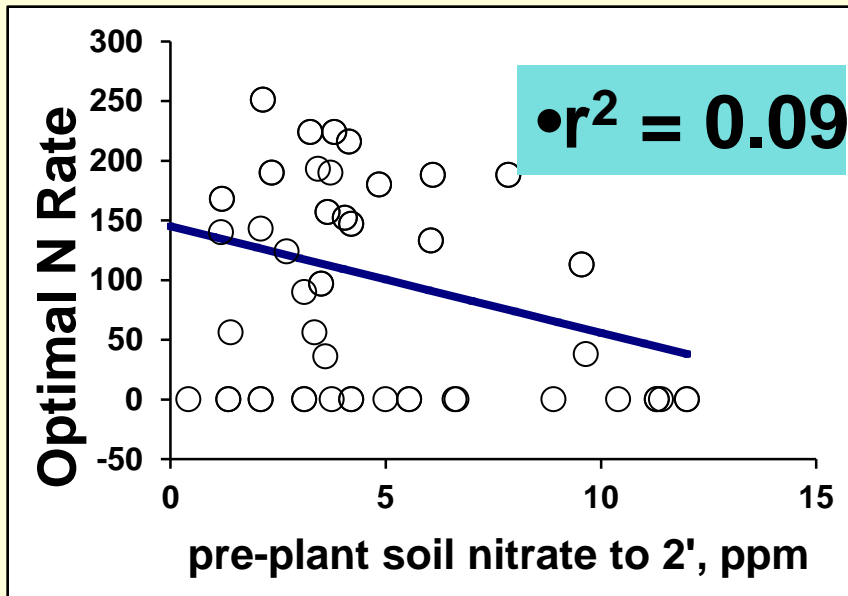


Sensors are usually mounted on fertilizer applicators



sensors

Advantage: most accurate data from 64 fields, 7 states



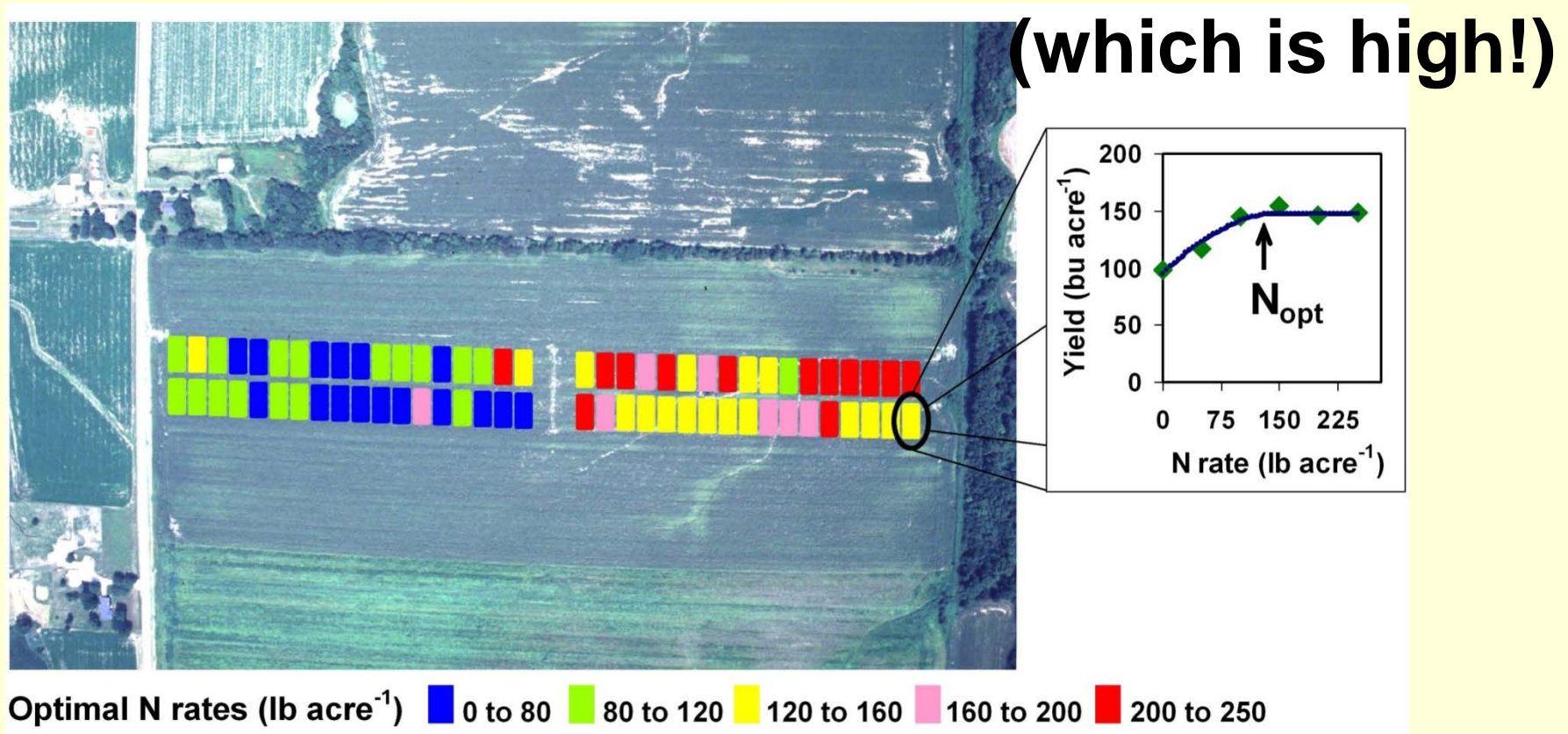
Disadvantage: Requires N application to growing crop

- Rarely practiced for corn in the corn belt

Most of the N

- Often practiced for:
 - Corn in the southeast
 - Many other N-requiring crops
 - Cotton
 - Wheat
 - Rice
 - Grass

Advantage: sensors can manage spatial variability in N need



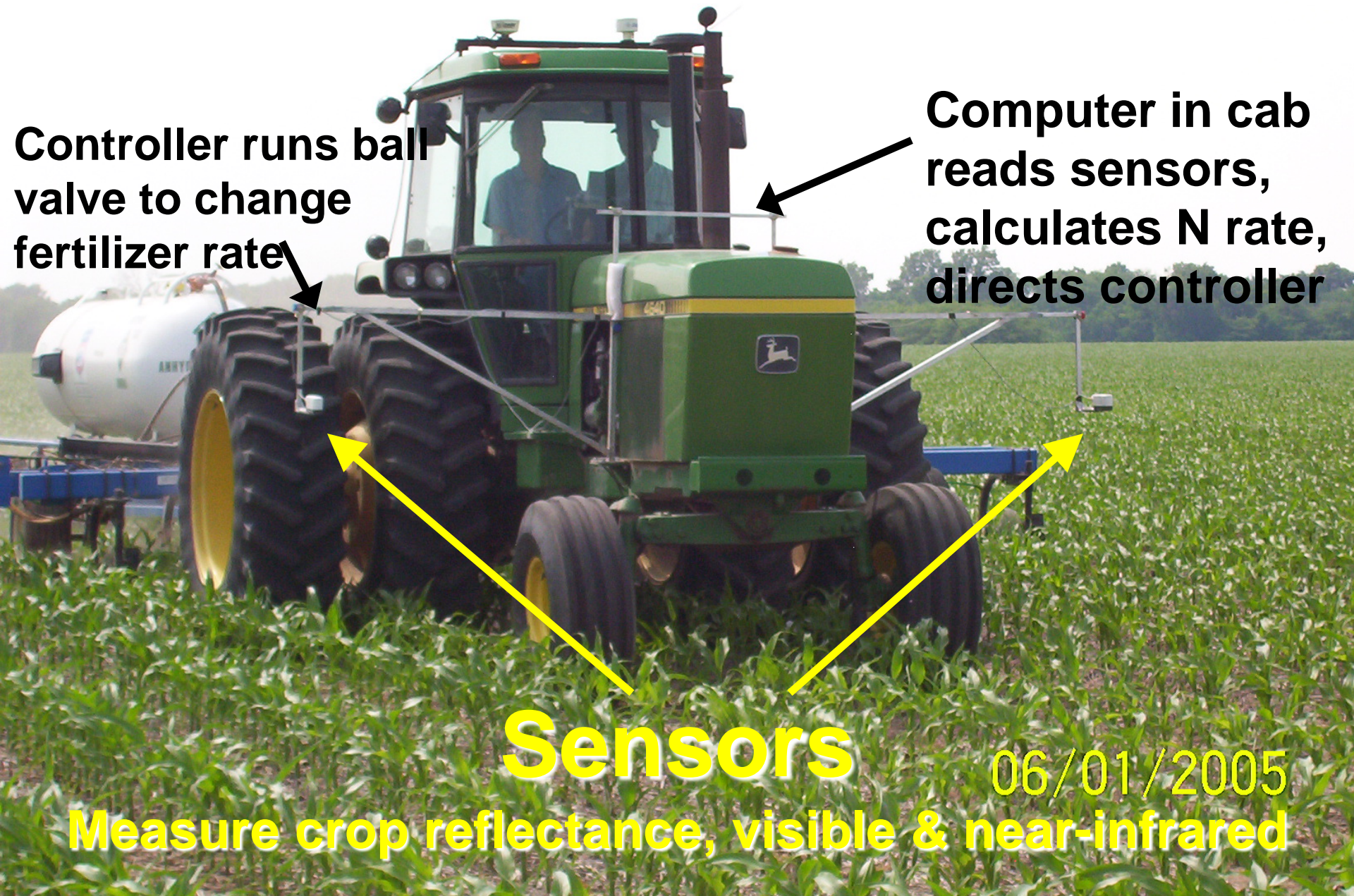
What happens when you apply 150 lb N/acre to the whole field?

Yes: Minnesota, Kansas, Missouri, Pennsylvania

No: Wisconsin

**A uniform N rate is
usually BOTH under-
and over-application**

Canopy sensors manage variability



Controller runs ball valve to change fertilizer rate

Computer in cab reads sensors, calculates N rate, directs controller

Sensors

06/01/2005

Measure crop reflectance, visible & near-infrared

Canopy sensors manage variability



Controller runs ball valve to change fertilizer rate

Computer in cab reads sensors, calculates N rate, directs controller

New N rate diagnosis every second
New N rate every second

Sensors

06/01/2005

Measure crop reflectance, visible & near-infrared

Disadvantage: Sometimes run out of time with tractor-based applicator

- Only corn; not on other crops
- Earliest successful use in corn at 1 ft tall
- Corn grows quickly
- If rain delays fertilization, corn may get too tall to drive a tractor through it
- Need high-clearance backup
- Or only use sensors on highly variable fields

**Advantage: Minimize vulnerability to
N loss in wet weather**

Central Missouri 2009

+ 68 bu/acre

153 N

**153
sidedress knee-high**

180 N

**180
at planting**

**Works best with a zero
to moderate rate of
preplant N**

**Not as good with high preplant N
rates, then making a decision
about whether a little more is
needed or not**

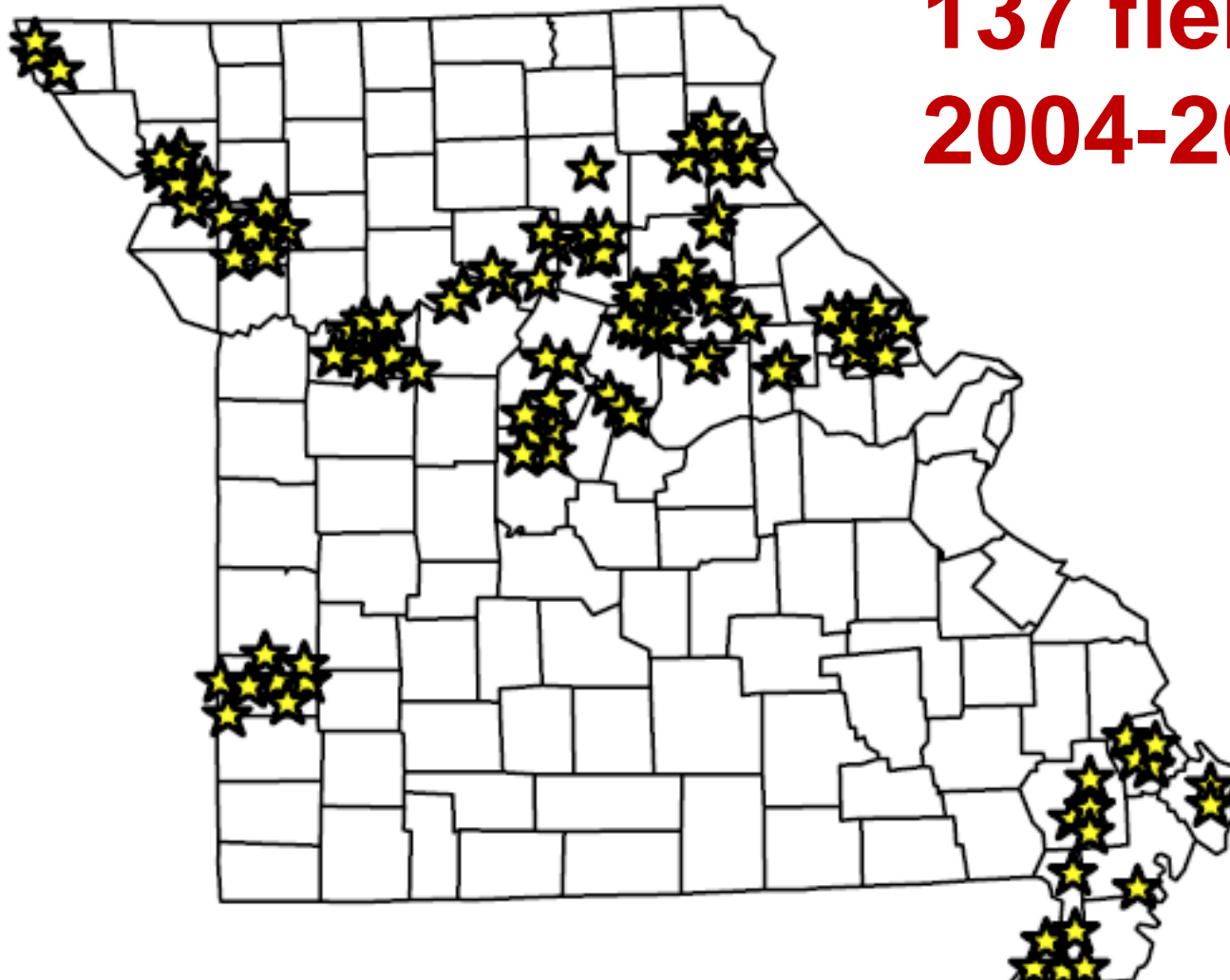
Requires a high-N reference area

- **small % of field**
- **Adjusts mainly for color change with crop stage; also genetics, weather, soil**

Easy for producers making split N applications

- **1 to 3 strips with high N rate per field while making pre-plant N applications**
- **If applying no N pre-plant, a plane is the ideal way to apply reference areas**

Demonstration program: started in 2004 to help farmers try this technology

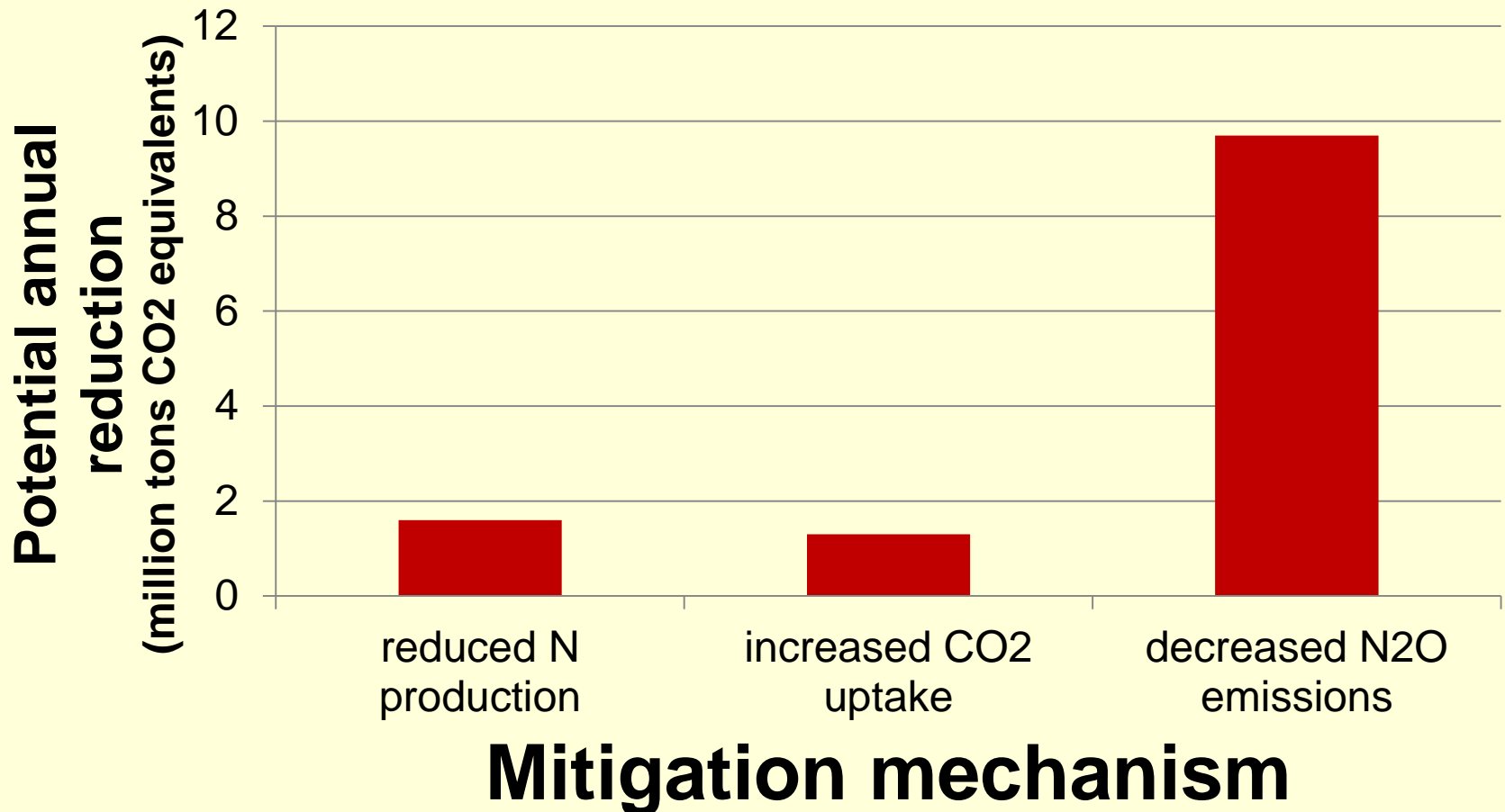


**137 fields,
2004-2009**

Sensor demo outcomes

- **55 replicated strip trials 2004-2008**
- **Increased corn yield by 2 bushels/acre**
- **Reduced N use by 14 pounds/acre**
- **Increased partial profit by \$17/acre**
- **Reduced 'surplus N' by 27%**
- **Based on Missouri interpretations for sensors**
- **Works with all N forms, placements**

Sensor-based N and greenhouse gas mitigation



Sensor-based N: interpretations an issue

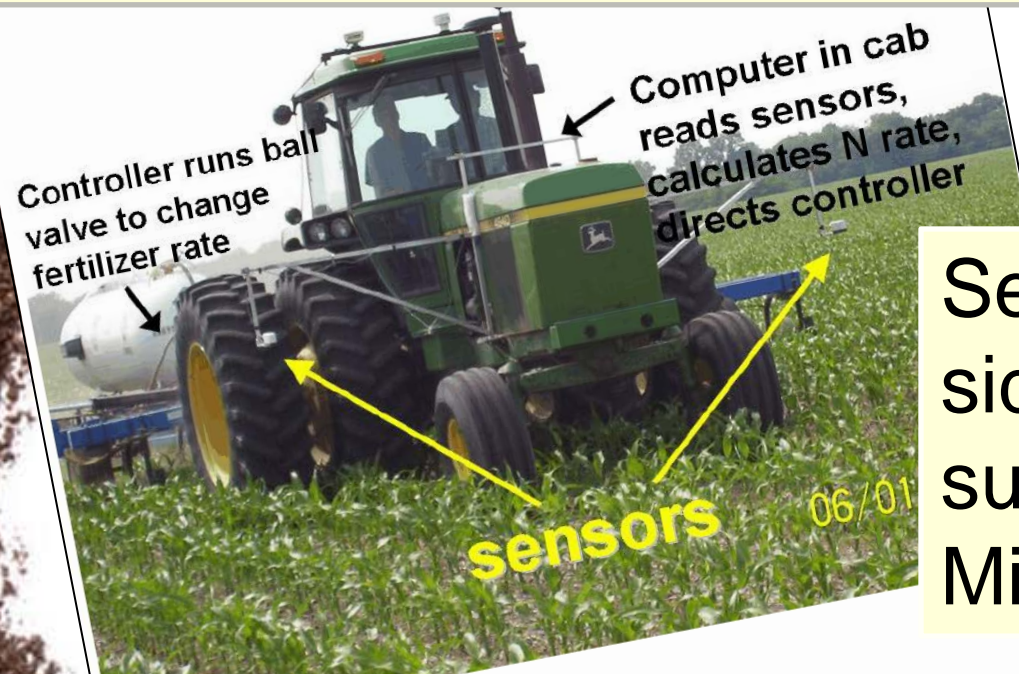
- Greenseeker sensor (Trimble): Many widely different N recommendation systems available
 - Some of this variability is probably appropriate due to regional differences
 - What isn't appropriate will shake out eventually
- OptRx sensor (Ag Leader): Introduced new and much more aggressive (higher N rate) interpretation system in 2012
 - My opinion: not appropriate for NRCS mission

Managing Nitrogen with Crop Sensors: WHY and HOW

Peter Scharf
University of Missouri

This manual is
available on my
web page:

<http://plantsci.missouri.edu/nutrientmanagement>



Sensor & meter-based
sidedressing has been
supported by EQIP in
Missouri for 5 or 6 years

Guidance: search Missouri technical note 35

Summary

- Accurate predictions of the amount of nitrogen needed by corn on individual fields is difficult
- Predictions can be improved by using an Adaptive Nutrient Management process
- The 590 Standard requires replicated strip trials to refine nitrogen recommendations
- Many tests and tools available to provide additional information about the nitrogen status of corn in replicated strip trials
- Use the tests and tools with replicated strip trials to improve N management

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