



Adaptive Nutrient Management: On-Farm Testing

**NRCS Webinar
June 7, 2012**

Tom Morris, University of Connecticut
Quirine Ketterings, Cornell University
Jim Camberato, Purdue University

Summary of ANM process

- Farmers sign up for 590 Practice Scenario Adaptive Nutrient Management
- Cooperating partner (consultant, extension, district person, agronomist from fertilizer dealer) discusses with farmers the practice they will evaluate
- Common treatments agreed to by farmers who will evaluate the same practice
- Protocols based on state 590 standard developed for evaluation including design and layout
- Data collection; Analysis, interpretation, presentation of results
- Winter meetings to learn from results
- Continue evaluations for at least 3 years

General NRCS Protocols for ANM

NRCS General Manual: 402.2; Adaptive Nutrient Management

The process is to be carried out by producers themselves, in cooperation with the land-grant university, or with other agencies and industry partners following prescribed protocols developed by the State NRCS, land-grant university, or other appropriate technical agencies and industry.

The results of adaptive nutrient management testing that meet the established protocols and are concurred with by NRCS and the land-grant university may be used in nutrient planning where appropriate. For adaptive nutrient management projects supported by NRCS, a final report of results must be provided to the NRCS State Conservationist.

Agronomy Technical Note No. 6

On-farm testing for ANM in 590 Standard is based on Agronomy Technical Note No. 6 and consists of strip trials with at least 4 replications (in process of being re-written)

Other details of protocols for strip trials, such as minimum length, will be in the revised Tech Note No 6

Webinar today will cover the basic protocols of on-farm testing using strip trials with 4 replications with yield as the measurement for evaluation

Third webinar on August 23 at 3:00 pm (Eastern) will cover tests and models used to supplement evaluations of yield

http://efotg.sc.egov.usda.gov/references/public/TN/Agronomy_Technical_Note_No_6.pdf

Benefits of on-farm testing

- Gain farm-specific knowledge through:
 - Systematic testing
 - Observation and measurement
 - Learning by discussion and communication
- Adapt recommendations and fine-tune management for improvement of:
 - Production efficiency
 - Farm profitability
 - Environmental stewardship

Successful on-farm testing

- Must be practical
 - Meaningful questions; farmers co-develop
 - Field scale plots
 - Use standard farm machinery
 - Collection of meaningful data
- Strip trials with statistically valid designs provide reliable testing and trustworthy results (negative or positive).
- Need thorough planning before going to the field.

Steps in On-farm Research

Step 1: Define the study question

Step 2: Plot layout and design

Step 3: Field site selection

Step 4: Implement trial

Step 5: Collect data

Step 6: Analyze data

Step 7: Learn from data and repeat

Step 1: Define the Question

- Simplify!!
 - One researchable question that allows for a comparison of 2-3 treatments max.
- Examples:
 - Can manure replace the need for starter N fertilizer?
 - Can sulfur application increase alfalfa yield?
 - Will yields increase if I apply more manure?
(two or three rate comparison)

Steps in On-farm Research

Step 1: Define the study question

Step 2: Plot layout and design

Step 3: Field site selection

Step 4: Implement trial

Step 5: Collect data

Step 6: Analyze data

Step 7: Draw conclusions and repeat

Step 2: Plot Layout and Design

- Randomize and replicate
 - Treatments must be repeated in side-by-side strips across the field.
 - Each pair of treatments should be repeated at least four times, although five or six is better.
 - Treatments should be randomly located within the pair.
 - One treatment may be favored over another if treatment 1 is always on the left and treatment 2 always on the right.

Example: Wheat yield variability

No treatments in field

Wheat yields (bu/A) in Side-by-Side Combine Strips

70
68
66
64
55
59
56
60

Winter wheat yield of 500-foot-long combine strips in a seemingly uniform area of a field near Moscow, ID (1992). Full header-width cuts 20 feet wide were harvested in each side-by-side 25 ft X 500 ft plots. Yields of adjacent strips varied as much as 9 bu/A or 14.4%.

<http://pnwsteep.wsu.edu/tillagehandbook/chapter10/100999.htm>

Example: Plot Layout and Design

Farmer's question:

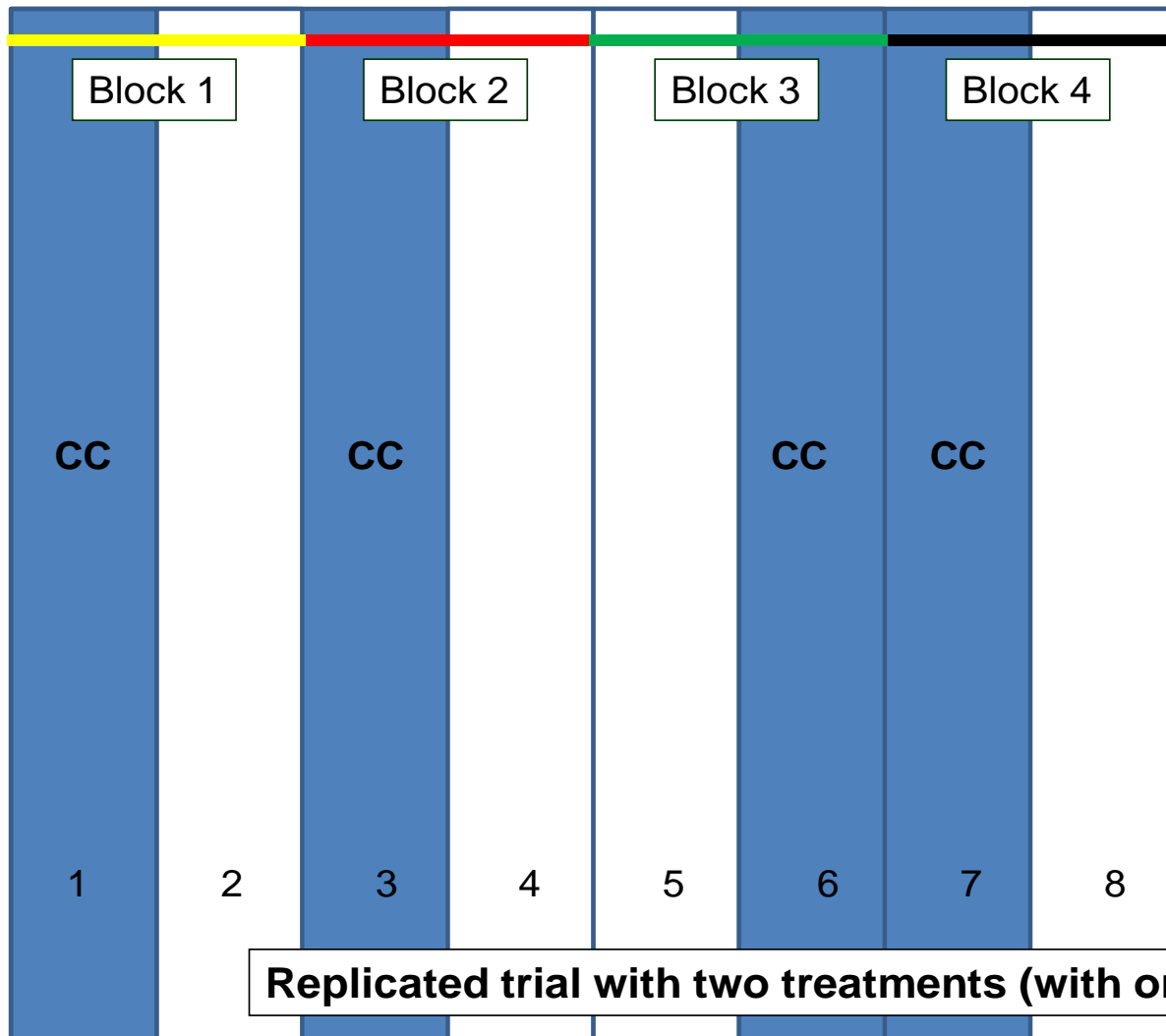
Does having a cover crop in the rotation increase yield of the following corn crop?

Design:

- Two treatments
 - With or without a cover crop
- Replicated 4 times, so 8 strip plots total
- Organized in sets of two (blocks)
- Randomized (with/without) in each set of two

Diagram of a Strip Trial

(complete randomized block design)



- Two treatments (with/without cover crop).
- Four replications
Organized in sets of two (blocks)
- Randomized within each set.
- Mark front+back corners of each plot (**plastic** flags!)
- Use extra markers (distance from road, tree, etc.).
- Mark with GPS coordinates if sufficient resolution).

How Wide Should Each Plot Be?

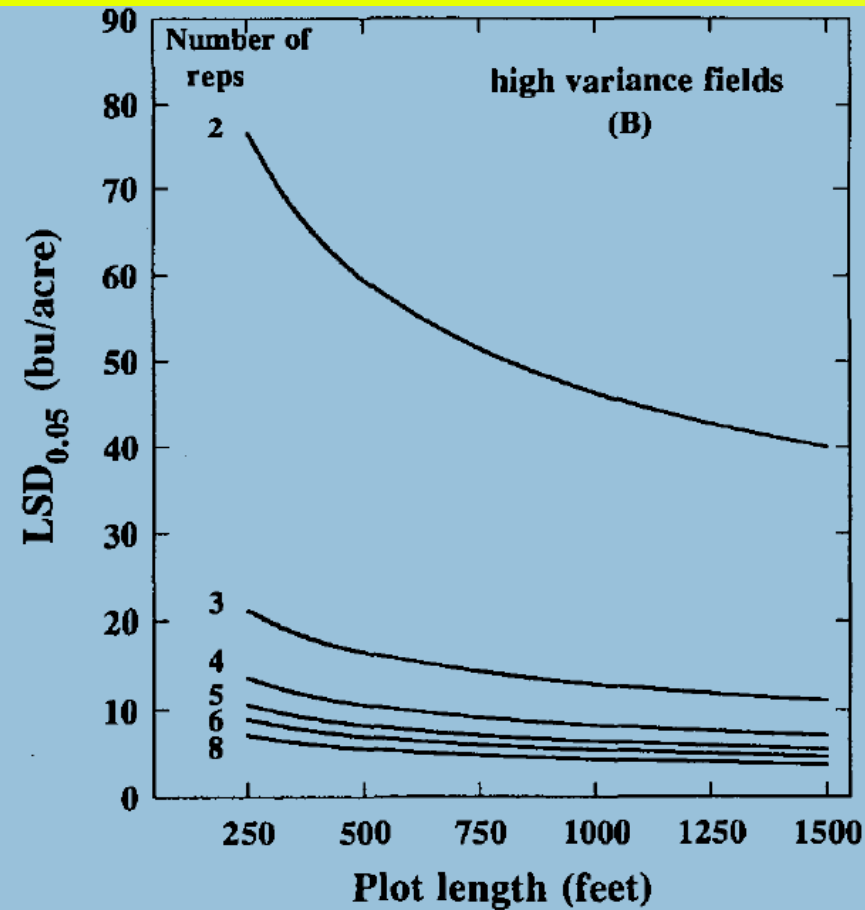
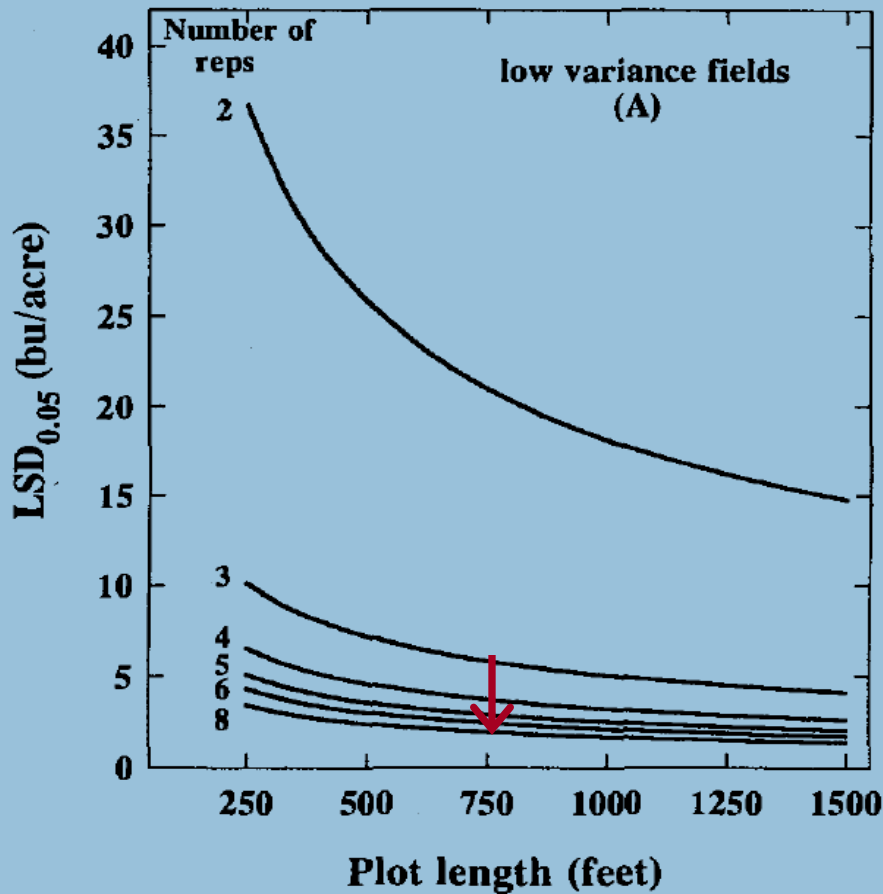
- Border rows are needed on each side of the plot to avoid edge effects. Width depends on farm equipment:
 - Shoot for plots that are two times the chopper or combine header width
 - 4-row chopper or combine = 8-row plots
 - 6-row chopper or combine = 12-row plots
- Application equipment needs to be considered:
 - If manure spreader = 40 feet, then plots should be at least 40 feet wide (16 corn rows at 30-inch spacing).
 - If fertilizer spreader = 50 feet, then plots need to be at least 50 feet wide (20 corn rows at 30-inch spacing)

How Long Should Each Plot Be?

- The variability of the yield in a strip has a large effect on the length needed for a plot
- The number of replications also effects the length of a strip
- Objective of the strip plots is to measure differences between treatments to find practices that maximize efficiency
- There is usually a “sweet spot” in design of an experiment where increasing the number of replications or length of strips provides little increase in our ability to measure differences

Effect of plot length on LSD values for wheat experiments with different numbers of replications.

Low variance fields vs high variance fields



Wuest et al., 1994. J. Prod. Agric: 7:211-215.

Data valid only for wheat in Pacific Northwest.

Harvest Equipment Effect on Length of Strips

For combines with yield monitors; the longer the strip the better, up to ½ mile

For harvest of forage crops like corn silage: Shoot for a truck load that is 75% filled in average year

Expected yield	Truck load	75% of truck load	Number of rows harvested	Optimal length
tons/acre	tons/truck	tons/truck	30-inch rows	Feet
25	10	7.5	2	~2600
25	10	7.5	4	~1300
25	10	7.5	6	~870
25	10	7.5	8	~655

How calculate size of field and length of strip for forage trial

- How big does the field need to be if I want to evaluate three nitrogen rates (0, 75, 150 lbs N/acre)?
- What is the ideal length of plots if I have 30-inch row corn and a 10-ton harvest truck and expect 25 ton/acre yields?
- Farmer has an 8-row planter and a 4-row chopper
- What would my plot plan look like?

Calculation: field size and length

- 4-row chopper, so ideal strip width is 8 rows, which works well as farmer has 8-row planter
- With 10-ton trucks, and 25-ton expected yield, 1,300 feet is needed to fill a truck 75% full
- Comparing three treatments with 4 replications, so a minimum of 12 plots
- Each plot is 8 rows wide so my field has to be 8 rows per plot*12 plots=96 rows wide (240 feet) and 1,300 feet long, which means the field has to be 7-8 acres (probably 15 acres)

3-treatment forage strip trial

Because fields are often irregularly shaped, this 7-acre trial may require a 15-acre or larger field

1,300 feet long

Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12
0 lbs N	75 lbs N	150 lbs N	0 lbs N	150 lbs N	75 lbs N	150 lbs N	0 lbs N	75 lbs N	0 lbs N	75 lbs N	150 lbs N
Replicate 1			Replicate 2			Replicate 3			Replicate 4		

96 rows wide; 240 feet

Steps in On-farm Research

Step 1: Define the study question

Step 2: Plot layout and design

Step 3: Field site selection

Step 4: Implement trial

Step 5: Collect data

Step 6: Analyze data

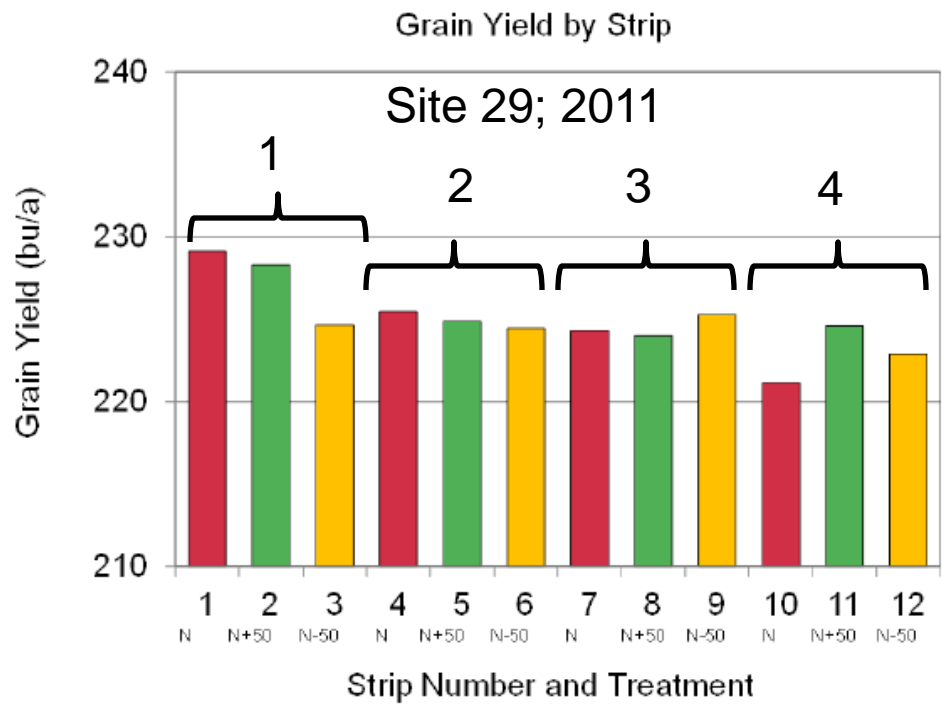
Step 7: Learn from data and repeat

Step 3: Field Site Selection

- Know the history of the field; base decision on that history (is it the right field for the test?)
- Select a field convenient for data collection.
- Uniform site!
 - Avoid fields with many soil types, slopes, irregular boundaries, and tile lines running parallel with the rows.
- Field should be large enough to allow for the design plus border rows around the plots.
- Don't use headlands for plot area.
- Flag, or locate with GPS, the plot and record treatment locations on a plot map.

Step 3: Field Site Selection

- Variability in conditions greatly affects the ability to detect significant differences in yield
- The greater the variability, the less your chance of detecting yield differences due to treatments.
- Place blocks (set of treatments) in such a way that variability within a block is minimal).

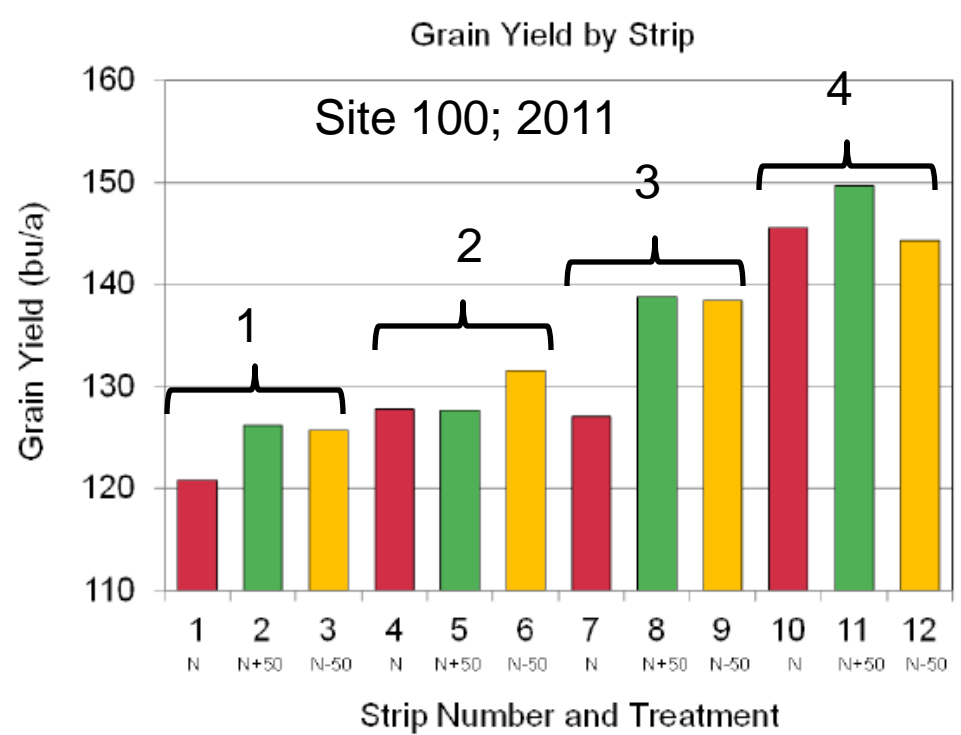


Grain yield in strip trials with 3 treatments and 4 replications or blocks:

1. Farmer normal N rate
2. Normal plus 50 lbs N
3. Normal minus 50 lbs N

Yield not too different across field at site 29; Blocking didn't help much

Yield greatly increased across field at site 100; Blocking reduced variability



Steps in On-farm Research

Step 1: Define the study question

Step 2: Plot layout and design

Step 3: Field site selection

Step 4: Implement trial

Step 5: Collect data

Step 6: Analyze data

Step 7: Learn from data and repeat

Step 4: Implement the Trial

Communication and recording:

- Discuss plot design and implementation with farm crew, not just the farmer, before you get into the field.
- Give everyone involved a copy of the plot plan.
- Establish importance of doing everything else the same other than treatments in the study.
- Indicate measurements in practical units (number of rows, length of field, etc.).
- Keep records of conditions during trial establishment.

Step 4: Implement the Trial



Step 5: Collect Data

- Determine what to measure depending on what the purpose of the trial is:
 - If the purpose is to increase yield
 - Measure yield
 - If the purpose is to improve forage quality
 - Collect forage samples
 - If the purpose is to increase net profit
 - Analyze cost and returns
 - If the purpose is to enhance nutrient use efficiency
 - Include measures such as soil testing or CSNT (for corn)

Measurement of Yield

- Measure comparable areas **in each plot**
- Measure plot lengths immediately after harvesting each plot
- Distance is multiplied by width of harvest equipment to determine harvested area
- Harvested area is used to calculate yield
- Take forage samples to determine dry matter

Step 5: Collect Data

12 row plot, harvest the inner 6



Be Careful with Data Collection

- Problems can occur that make the plot unusable (weed patches or misapplied crop inputs, planter skips, etc.).
- The best designed field plots are of little value if data are not collected accurately.
- Monitor plots frequently in the growing season.
 - Record crop inputs and field observations.
 - Emergence/stand, weed/insect damage, soil conditions, weather.
 - Record yields and additional measurements appropriate for the research question (e.g. CSNT).

Typical Data to Collect

- Take field notes:
 - Field history
 - Soil test
 - Fertility program
 - Planting conditions
 - Field operations and observations
- Weather
 - Rainfall
 - Growing Degree Days
- Insects, weeds and diseases
- Crop growth and development

Assume you will lose trials... on research farms also

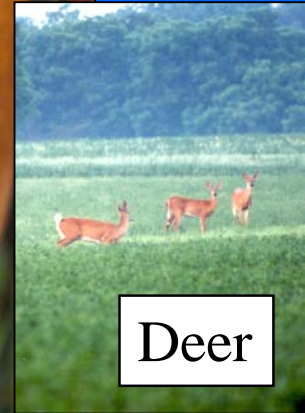
Things happen, move on:

- Not unusual to lose 10% of trials
 - Failed weed control
 - Bird damage
 - Planter skips
 - Waterlogged conditions
 - Had to be replanted (not possible for starter fertilizer trials.....)
 - Uncertainty about what plots/treatment

Willsboro guests shared our yields.



Birds



Deer



Corn borer



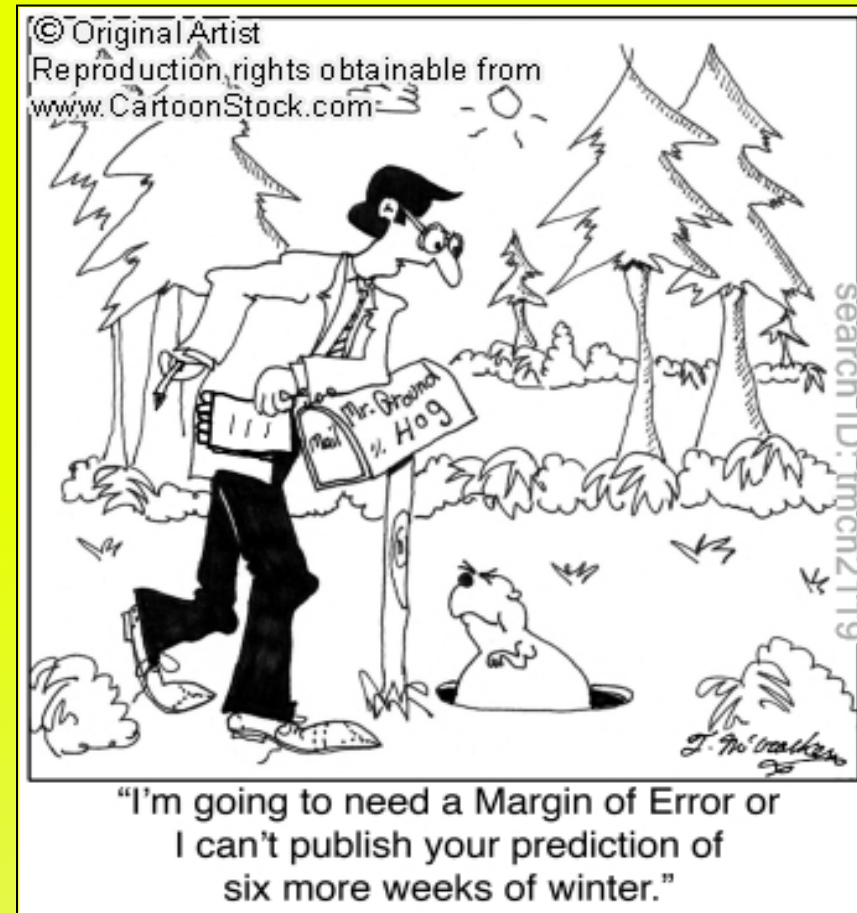
Bears?

Calibrated yield monitor allows continuous harvesting



Step 6: Summarize + Analyze Data

- Recognize field variability
- Use statistics to analyze the data
- Summarize results by individual trial and in aggregate if more farms were involved
- Present results in a format that is easy for farmers to understand and use



Analyze the Data

It is easy to lie with statistics, but it is easier to lie without it!

- Statistics are used to determine if treatment differences are real (resulting from the treatments) or due to chance.
- The probability that a difference between treatments could occur by chance is the p-value.

Treatment	Stand count
	Plants/acre
Material A	33,522 a
Material B	31,695 a
Material C	32,631 a
Material D	29,776 a
P value	0.56

Typical cutoff for significance is 0.05
(for illustration purposes only)

Statistical Differences

- In research reports, statistical differences are often indicated by small letters a, b, c etc.

Treatment	Yield
1. Surface applied manure	20 c
2. Spring incorporated with aerator in one hour	23 b
3. Spring incorporated with chisel in one hour	24 b
4. Injected	28 a

Questions:

1. Does incorporation of manure increase yield?
2. Is there a yield difference between incorporation with aerator and chisel?
3. Does injection increase yield as compared to chisel incorporation?

Least Significant Difference

- Calculation of the L.S.D. (Least Significant Difference) value will show the minimum difference needed between averages to be a real difference.
- Ask university staff to help with data analysis.
- Software available.



Results from one strip trial

Significant at 0.05; LSD = 4.3 bu

2 treatments: 84 and 168 lbs N/acre; 84 lb difference

Yield increase = 9 bu/acre or \$36.000 at \$4.00/bu

Cost for 84 lbs N at \$0.40/acre = \$33.60

Net return to N = \$2.40/acre

Strip	N (lbs A)	Yield (Bu A)	Stalk (ppm)
1	168	249	5700
2	84	242	1810
3	84	238	634
4	168	249	2230
5	84	237	230
6	168	250	2020
7	84	238	884
8	168	244	4450
Avg	84	239 a	890 a
Avg	168	248 b	3600 b
9 bu increase = \$36.00 84 lbs N = \$33.60 (\$0.40) Net \$2.40			

Optimum Rate Questions

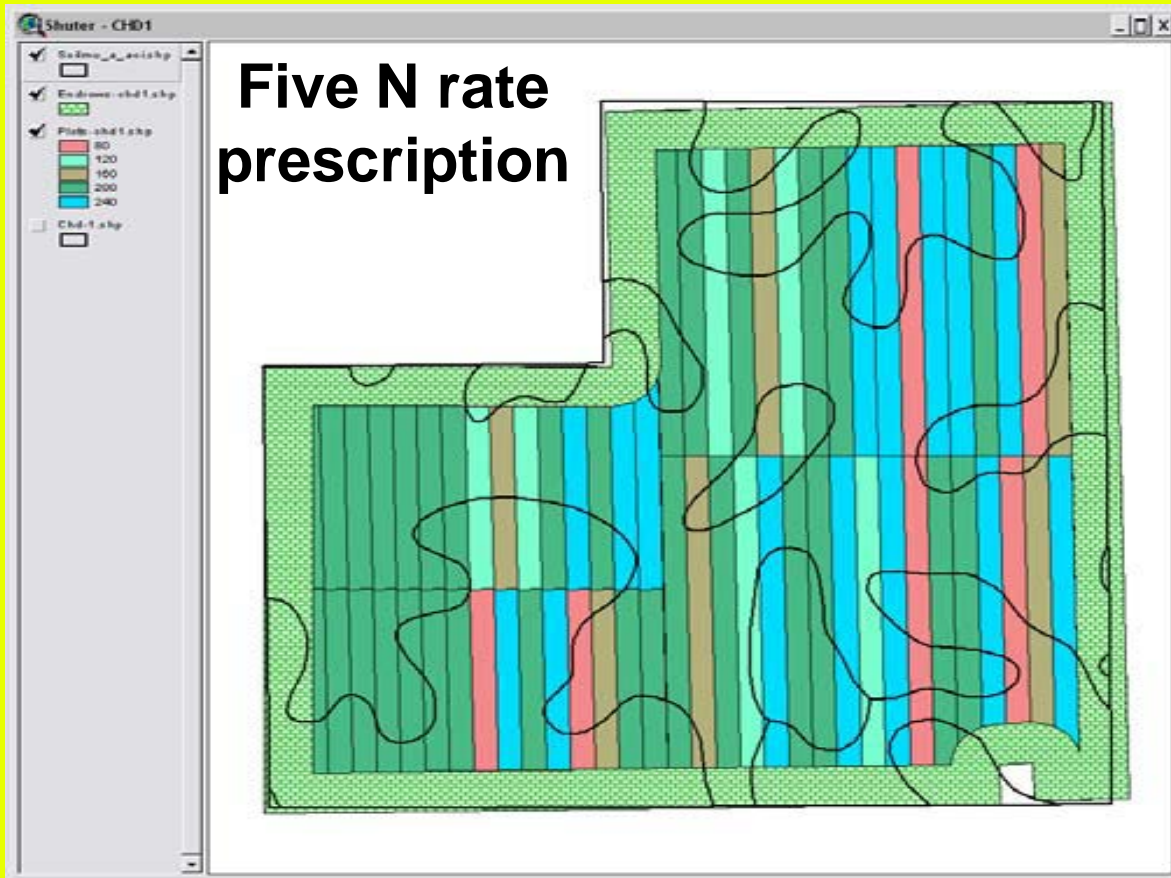
- How much do I need? How do I define an optimum rate?
 - Nitrogen or other nutrient
 - Manure?
 - Seeding rate



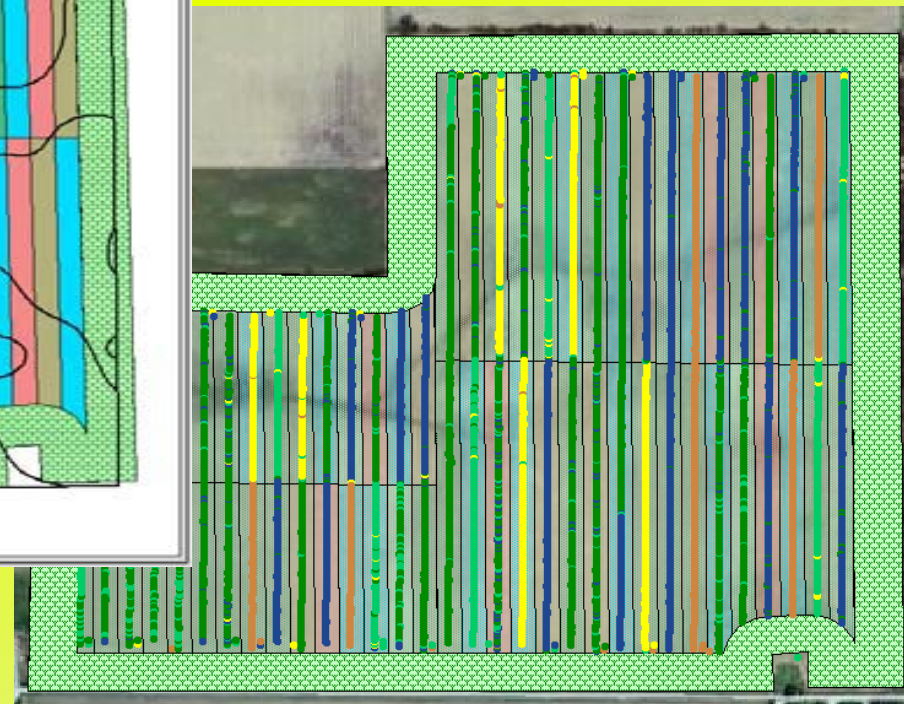
Nitrogen Rate Strip Trials

- At least 4 N rates are needed, replicated 4 or more times
- At least 1 N rate needs to reduce yield and at least 1 N rate should be above the optimum
- A control (no N) should be included where no response to N is possible

Prescription/application maps minimize errors



As-applied map

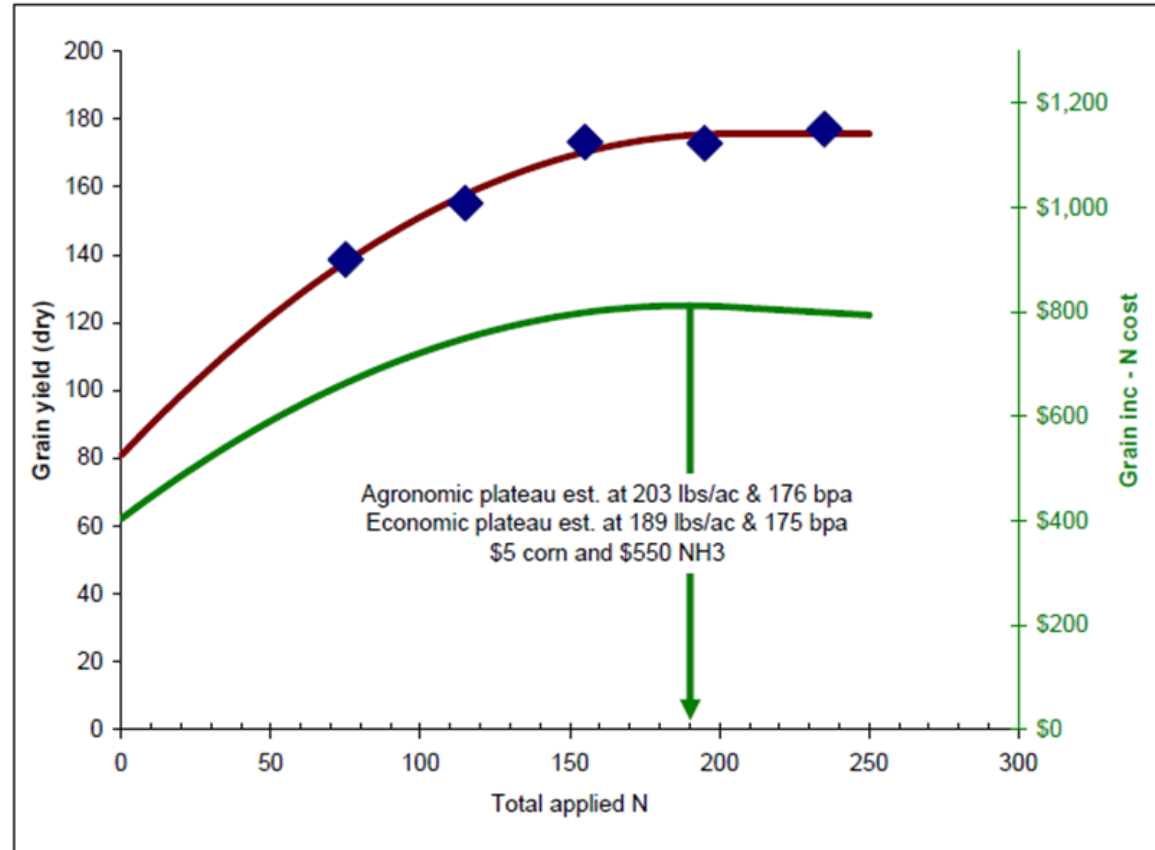


Statistical analysis to find optimum

2010 Purdue On-Farm N Rate Trials

Soils: Rensselaer, Crosier loams
Tillage: No-till
Prevcrop: Soybean
Hybrid: Beck's 6733 HXR (114-day RM)
Rates & reps: 5 rates, 5 reps
Planter:
Seedrate: 29,000
Planted: 5-May
Starter N: 30 lbs N in 2x2 (incl. in total N rates)
Sidedressed: 8-Jun
Sidedress N: NH3
SD applicator:
Fungicide:
Harvested: 14-Oct
Combine:
Yield Monitor: None, used weigh wagon
Plot size: 16 rows x 2132ft (harvested center 8)

TotalN	GrnMst	GrnYld	
75	na	138.6	c
115	na	155.2	b
155	na	173.2	a
195	na	172.8	a
235	na	177	a
LSD 0.10		4.7	
C.V.		2.6	



Definitions

GrnMst: Grain moisture

GrnYld: Grain yield, adjusted to 15% moisture

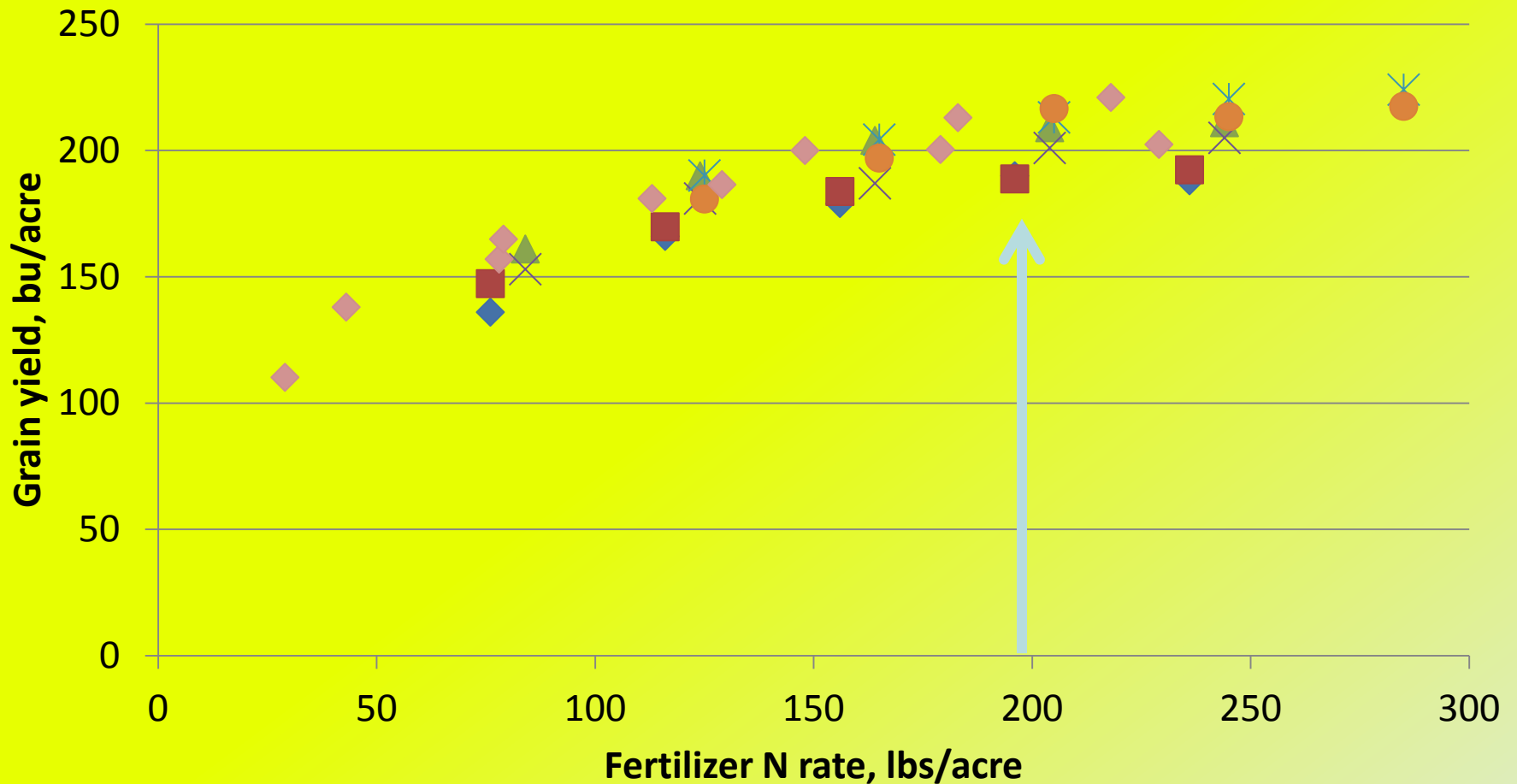
LSD 0.10: Least Significant Difference at alpha = 0.10. Values within same column followed by same letter are statistically similar.

C.V. "Coefficient of variation"; a measure of the variability within the study, low values = low variability better data)

na Not available

Multi-year optimum N rate trial

◆ 2006-Fld A ■ 2006-Fld B ▲ 2008-Cy × 2008-Ce ✱ 2009-Cy ● 2009-Ce ◆ Other farmers



Calculate Practical/Economic Significance of Data

- If the treatments cause a significant difference ($P < 0.05$), the difference is real.
- Then, determine where cost differences between treatments occurred such as seed, fertilizer, pesticides, tillage, and labor costs.
- The additional dollars of income from increased yield can then be weighed against the possible increased (or decreased) costs for that treatment.

Environmental Significance

- Consider benefits such as improved soil quality and reduced loss to environment.
- For example, for nitrogen fertility trials, use tools such as the Corn Stalk Nitrate Test (CSNT)
- Or use soil testing to evaluate soil test P trends.



Steps in On-farm Research

Step 1: Define the study question

Step 2: Plot layout and design

Step 3: Field site selection

Step 4: Implement trial

Step 5: Collect data

Step 6: Analyze data

Step 7: Learn from data and repeat

Step 7: Learn from Data, Repeat

- Be objective when review results. Learn from negative results. Surprises will occur.
- Discuss with farmers what could have caused the outcome.
- Repeat the same research multiple years, until you and the farmers are comfortable with the results under varying conditions.



Plan How Learning Will Occur

- Adults learn best when the learning is through discussion about problems they are interested in
- Results from strip trials often show different yield results than farmers expect
- This “problem” of different yield results than expected can be solved by discussion about how and why the results are different than expected
- Farmers are naturally inclined to discuss results from their farm

Set up Winter Meetings to Take Advantage of How Adults Learn

- Have results in format for easy discussion
- Don't use lecture format except at start to set up discussions
- Don't provide answers to farmers' questions about what is the "correct" practice for their fields
- Lead interactive discussions about what the results mean for the individual farmer and for farmers in the region
- The "correct" practice is the one that fits the data and the farm

The Bigger Picture

One Trial? Or More?

“A single trial has value, particularly to the grower on whose farm it was conducted. However, there is much more value in looking at data from many trials, whether they are collected from farmers in a local group or pooled from across the state and across time.”

Iowa Soybean Association

Aggregation
and
comparison to
other farms
with similar
soil types and
practices
builds
confidence
and adoption

Corn Nitrogen Rate Calculator

Finding the Maximum Return To N and Most Profitable N Rate

A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

State: Indiana - East & Central

Number of sites: 39

Rotation: Corn Following Soybean

Non-Responsive Sites Not Included

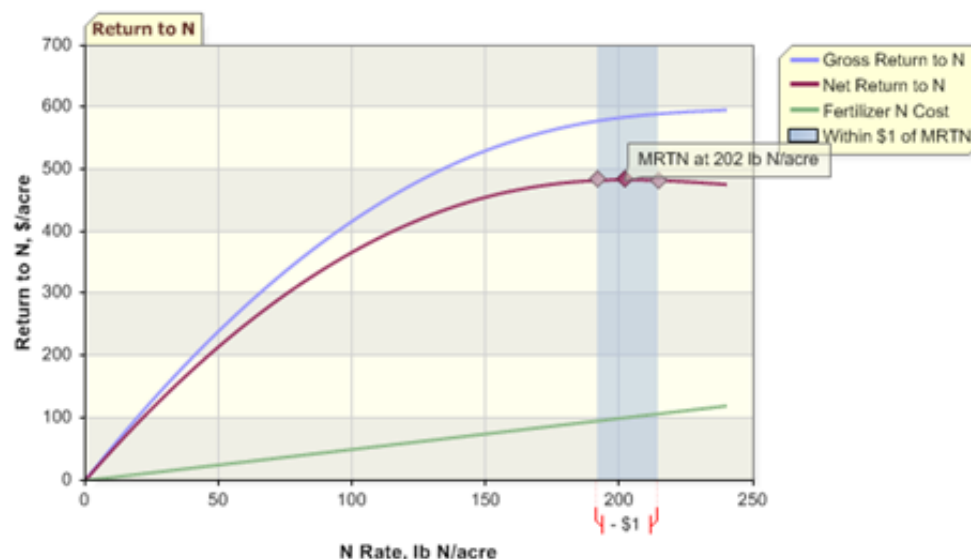
Nitrogen Price (\$/lb): 0.50

Corn Price (\$/bu): 5.00

Price Ratio: 0.10

MRTN Rate (lb N/acre):	202
Profitable N Rate Range (lb N/acre):	191 - 214
Net Return to N at MRTN Rate (\$/acre):	\$484.04
Percent of Maximum Yield at MRTN Rate:	99%
Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre):	246
Anhydrous Ammonia (82% N) Cost at MRTN Rate (\$/acre):	\$101.00

Most profitable N rate is at the maximum return to N (MRTN).
Profitable N rate range provides economic return within \$1/acre of the MRTN.



Contact Information

Jim Camberato
Purdue University
Department of Agronomy
jcambera@purdue.edu

<http://www.ag.purdue.edu/agry/Pages/jcambera.aspx>



Tom Morris
University of Connecticut
Dept. of Plant Science and Landscape Architecture
thomas.morris@uconn.edu

<http://www.plantscience.uconn.edu/morriscv.html>



Quirine Ketterings
Cornell Nutrient Management Spear Program
Department of Animal Science, Cornell University
qmk2@cornell.edu – <http://nmsp.cals.cornell.edu>

