Manured fields and N fertilization: How to improve your guess at the correct N rate

Manure management

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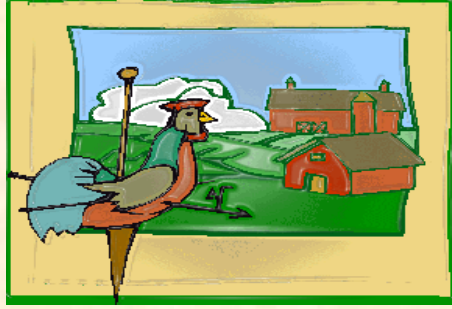
Assumptions underlying UConn's N management

Manure management

- N recommendation will always be a guess
  - Rainfall after N application changes amount of N available
- Impossible to accurately measure N availability from manure, both this year's applications and previous years
- Yield goal system doesn't work because most N uptake by corn is from soil, especially on manured fields (assumptions not for irrigated, Coastal Plain soils with no manure history, low OM, high sand)
- Cornfields are biological systems and cannot be "engineered"

Conclusions from assumptions



Manure management

- Need to use biological concepts to manage N
- Need to manage field-by-field; Need field-by-field records that can be easily summarized across years to improve guess with time
- Need a report card to evaluate guess at amount of N needed
- Money is limited, so should target money where will do most good, i.e., at “back end” for field records and report card info, and not at “front end” for manure analysis

Summary of talk

Manure management

- Data from literature about sampling manure for N content
- Evaluation of current system for N recommendations using results from 205 yield response trials on manured fields
- N recommendation system in CT and Nutrient Management Plans in CT
- Point source vs nonpoint source pollution

Sampling for N content of liquid manure

Manure management

- Many factors influence N content: type of manure, type of storage, length of time in storage, etc.
- Can minimize factors by sampling liquid manure at time of application
- But, accurate sample only obtained if you agitate pit, usually need to agitate for a few hours
- Need to collect 3 to 5 subsamples and composite into one sample to get plus/minus 10%
- If don't agitate, need 20 to 75 subsamples to get plus/minus 10%

(Dou et al., 2001. J. Environ. Qual. 30:1432-1437)

Sampling for N content of solid or semi-solid manure

Manure management

Difficult to quantify due to variability

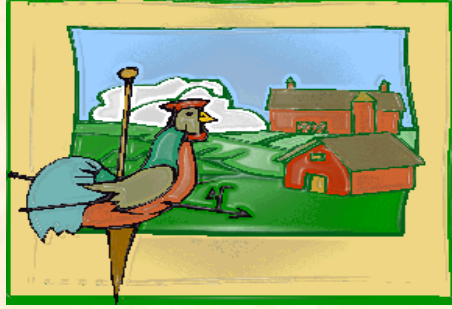
Sampling piles, feed lots, scrape and haul, or bedded pack systems:

Need 13 to 55 subsamples to get plus/minus 10% for total N

Need 121 to 443 subsamples to get plus/minus 10% for ammonium N

(Riech-Hinz, et al., 1996. J. Prod Ag. 9:82-86)

Factors influencing N availability after sampling



Manure management

1. Uncertainty in rate of application
2. Variability in application
3. Losses after application but before incorporation; volatilization
4. Losses after application if no-till and not incorporated; rainfall and temp dependent
5. Uncertain availability of inorganic N (nitrate and ammonium) from organic N portion of manure
6. Uncertain availability of inorganic N from previous applications of manure

N available from previous manure applications

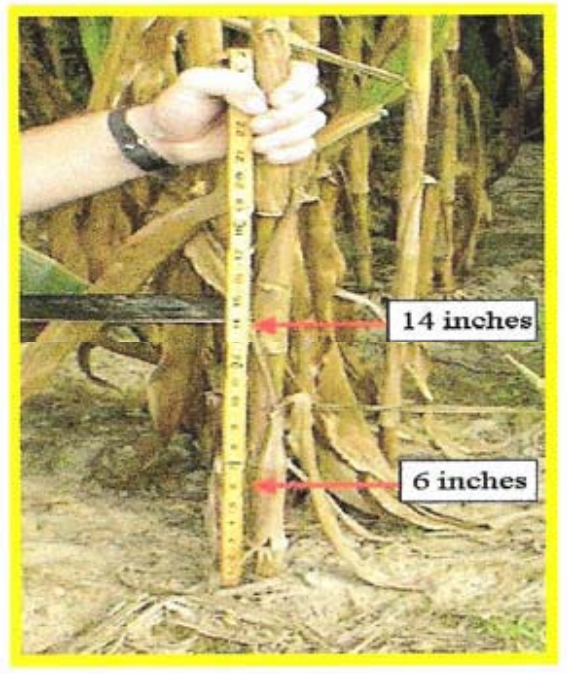
Manure management

- 64 cornfields in Connecticut no application of manure or N fertilizer for the growing season
- All fields had a history of manuring
- Median cornstalk nitrate concentration for the 64 fields was 4,700 ppm
- Range from 125 to 11,900 ppm
- Less than 250 ppm = high probability of N deficiency
- 250 to 2000 ppm = optimum
- Greater than 2000 = excessive

Manure management

Cornstalk nitrate test

- Is the report card we need to evaluate our guess
- Collect sections of lower cornstalk (cut at 6 and 14 inches above ground) between ¼ milk line and 3 weeks after black layer
- Nitrate-N concentrations in stalk provide estimate of N availability during growing season
- Interpretation of values
  - < 250 ppm = likely deficient
  - 250 to 2000 ppm = optimum
  - > 2000 ppm = excess



How manage uncertainty?

Manure management

- Our current system uses a “yield goal or general guideline approach” for N recs
- Expected N needed by corn: 150 to 200 lbs/a for corn-corn; 100 to 150 lbs/a for corn-beans
- Estimated amount of N available from manure: from manure analysis and expected amount of available N (80% or 100% for swine; 65% for chicken; 30 to 40% for dairy and beef; liquid dairy 40 to 60%)

Problems with yield goal or general guideline approach

Manure management

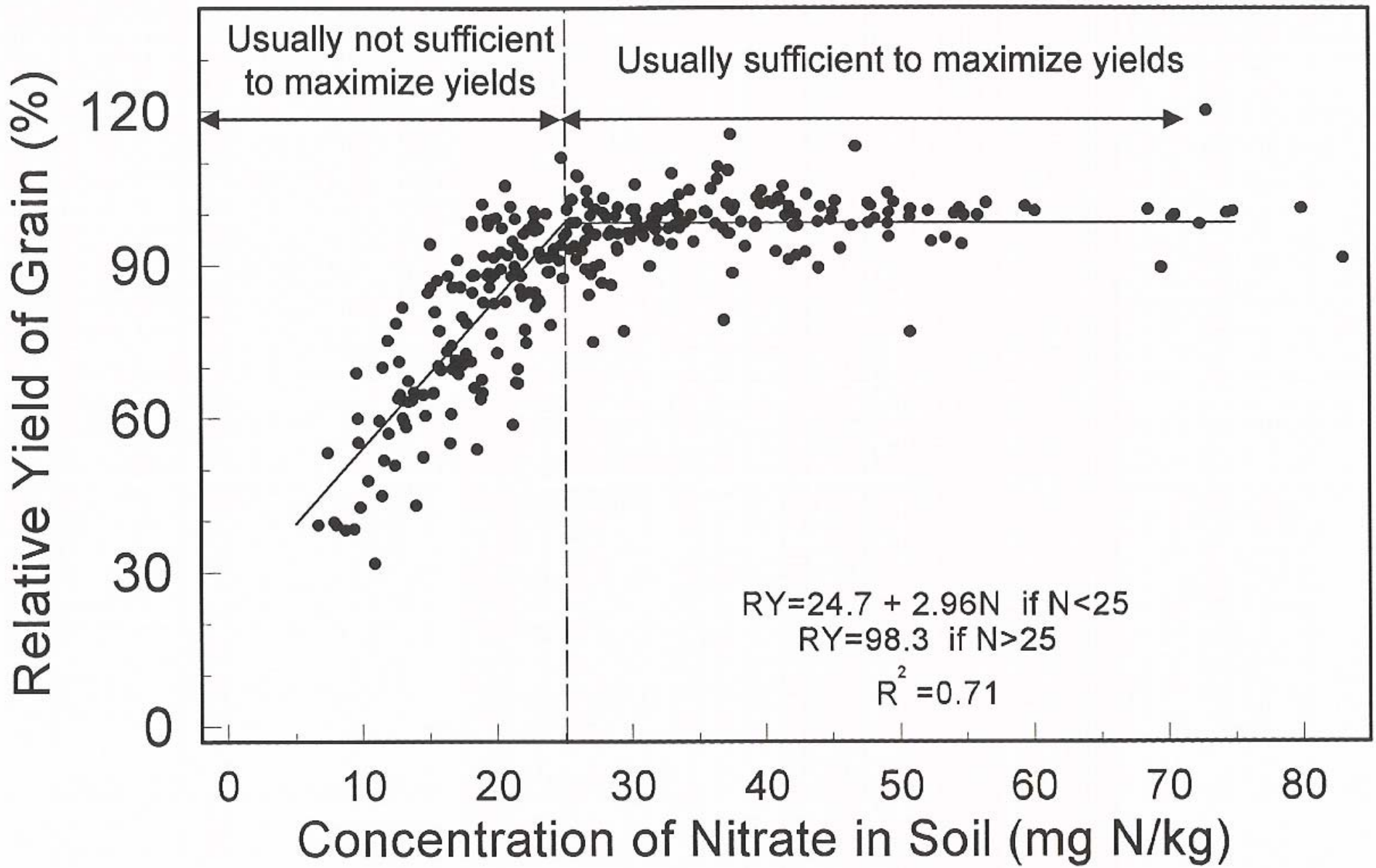
- Variability of measured numbers not shown (manure analysis, application rate)
- Variability in assumed numbers not shown (% N available from manure; amount of N available from soil)
- Is an engineering approach to describing a biological system
- N availability is controlled by biological factors that cannot be “engineered”

How evaluate “yield goal or general guideline approach”

Manure management

- The best way to evaluate is to measure availability of N to the plant during the growing season = cornstalk N test
- Next best evaluation method is to measure yields
- Soil testing approaches to making fertilizer recommendations are evaluated by measuring yields
- Example: Measure yields from many fields with soil test values from below optimum to above optimum
- Should do the same for YG system

PSNT for soil nitrate



YG N recs rarely evaluated in yield performance trials

Manure management

- But, farmers routinely evaluate YG N recommendations
- Surveys of farmers show that they do not reduce N fertilizer rates as much as recommended by the YG system
- Don’t take all the N credits

A study in Iowa evaluated the YG system for N recs

Manure management

- 205 trials on cornfields in 28 counties from 1992 to 1997
- Types of manure: 22 beef; 9 dairy; 149 hog; 9 poultry; 16 two or more manure types
- Application times: fall, winter, spring
- Farmers provided info about rate, type and timing of manure applications
- Manure analysis available for about 1/3 of sites
- (Hansen, et al., 2004. Performance-based evaluations of guidelines for N fertilizer applications after animal manure. Agron. J. 96:34-41)

A study in Iowa evaluated the YG system for N recs

Manure management

- Each trial had 16 plots; Each plot was 4 rows by 40 feet
- 4 treatments: 0, 30, 60, 90 lbs N/acre; 4 reps
- N applied by hand within 7 days after soil samples collected for the PSNT; form of N was ammonium nitrate or urea
- Soil samples for PSNT collected when corn plants were 6 to 12 inches tall
- Grain yields measured by hand harvesting

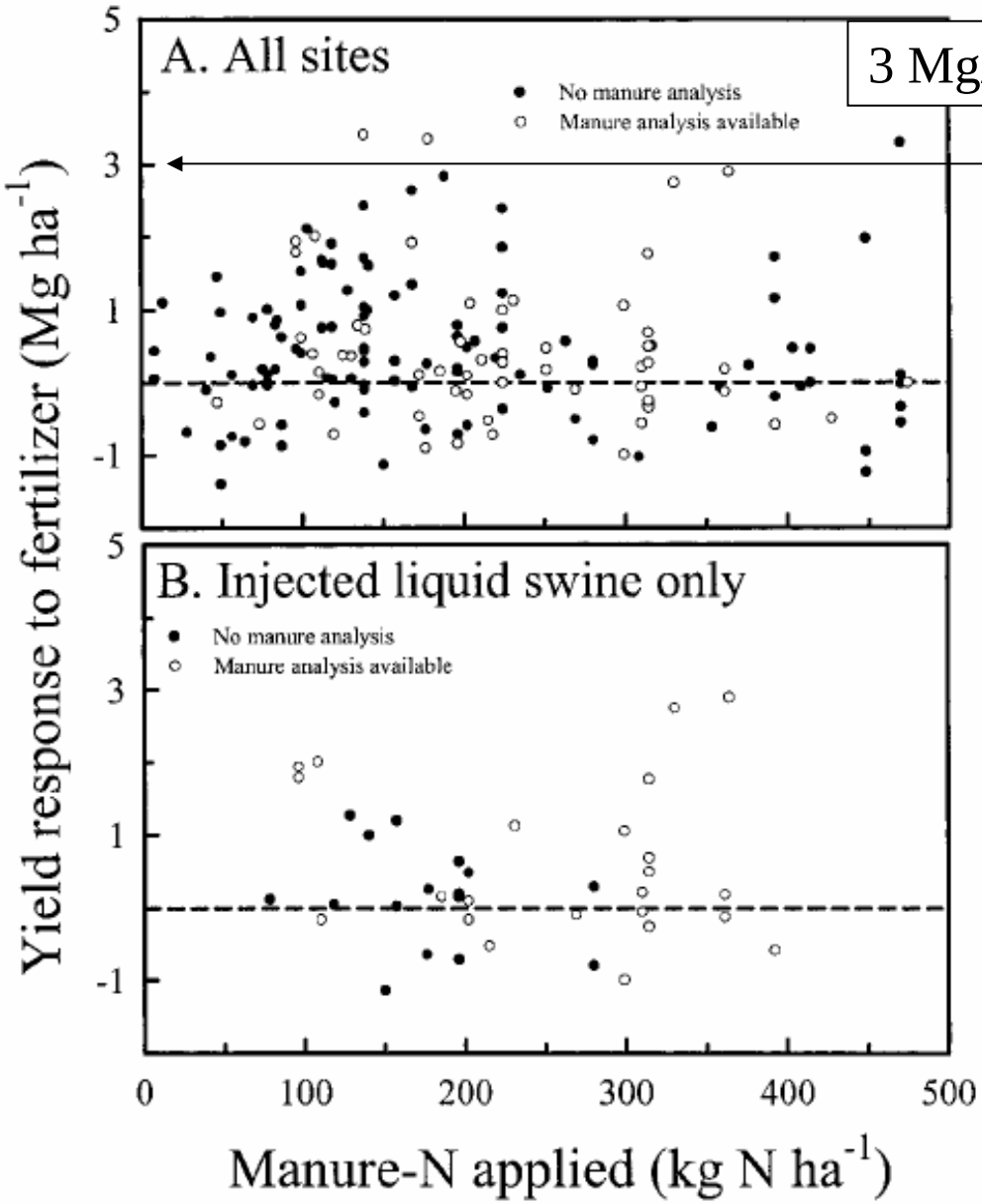
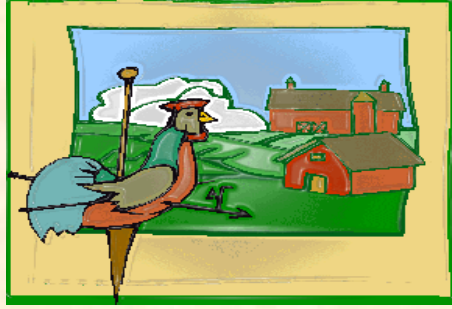


Fig. 2. Relationships between rates of manure-N application and corn yield responses to fertilizer N applied at 100 kg ha^{-1} across (A) all sites and (B) sites treated with liquid swine manure that was injected into the soil.

3 Mg/ha = about 48 bu/a



Manure management

No relationship between estimated amount of manure N applied and yield response to 90 lbs N/acre

Injected hog manure has no relationship

100 lbs N/acre = 112 kg N/ha
1 Mg/ha = 15.9 bu/acre

3 Mg/ha = about 48 bu/a

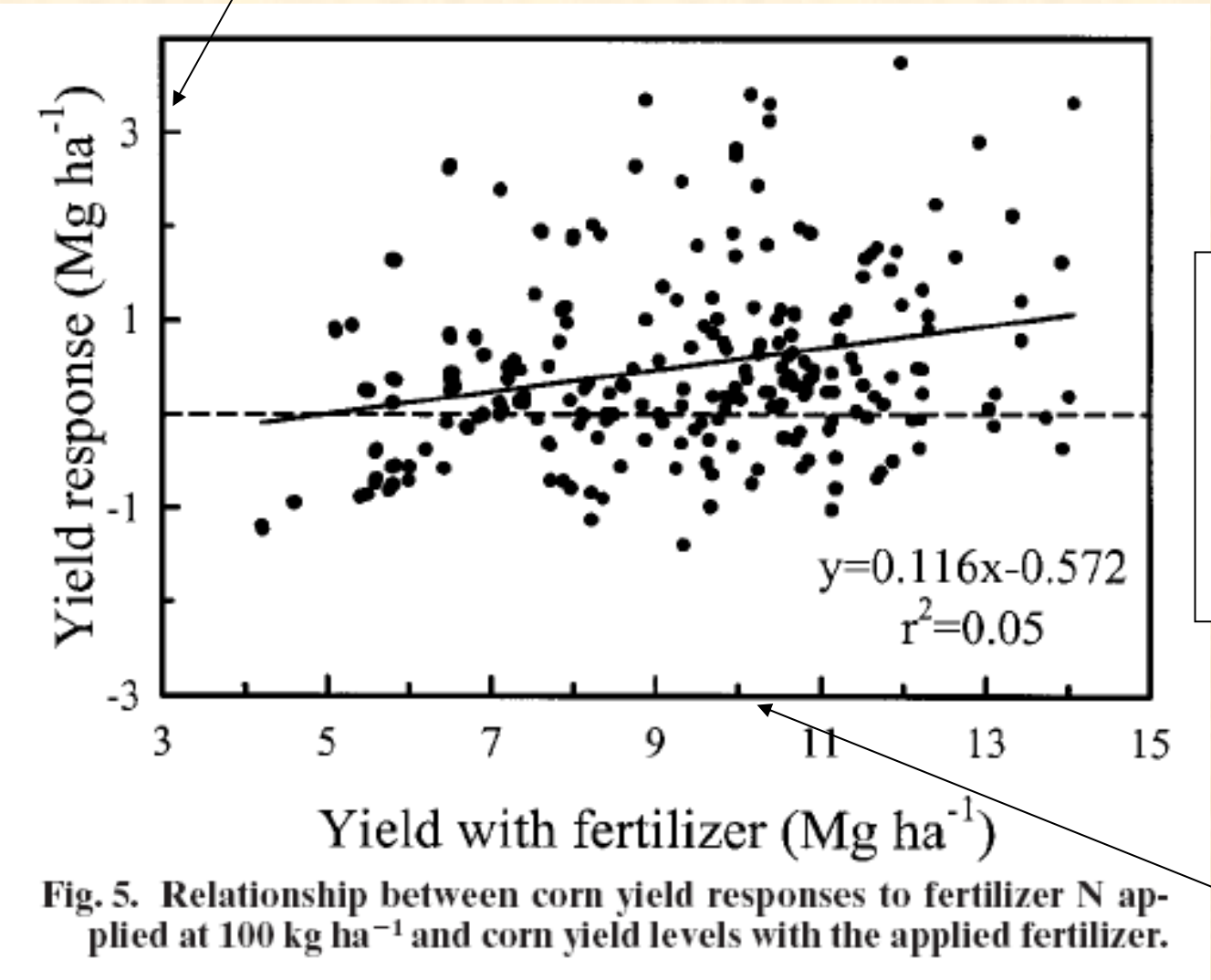


Fig. 5. Relationship between corn yield responses to fertilizer N applied at 100 kg ha^{-1} and corn yield levels with the applied fertilizer.

Manure management

Yield at 90 lbs N/a related to yield response, but only explains 5% of variability

10 Mg/ha = 159 bu/acre

3 Mg/ha = about 48 bu/a

Manure management

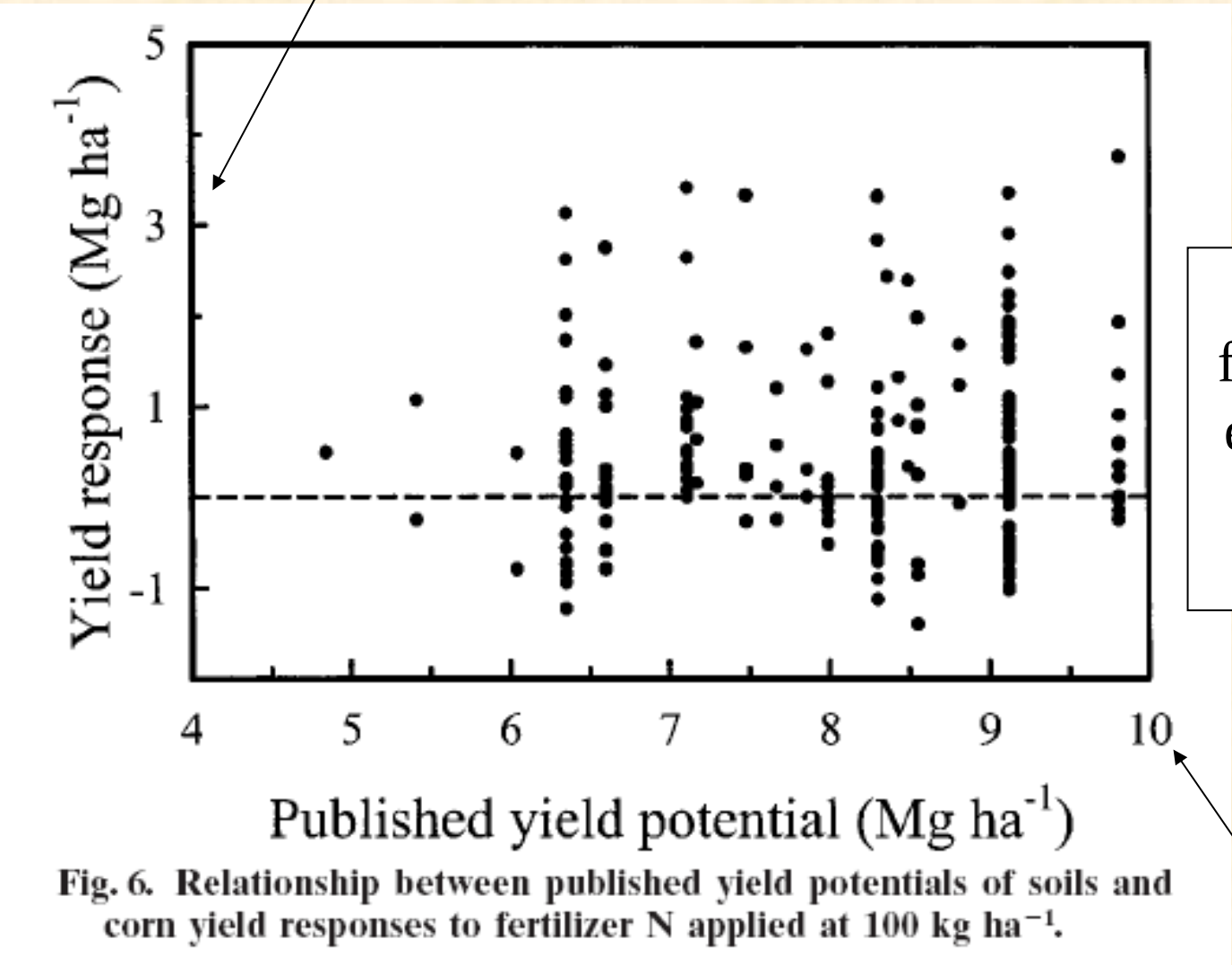


Fig. 6. Relationship between published yield potentials of soils and corn yield responses to fertilizer N applied at 100 kg ha^{-1}.

Yield potentials from soils database explained only 2% of variability in yield response

10 Mg/ha = 159 bu/acre

3 Mg/ha = about 48 bu/a

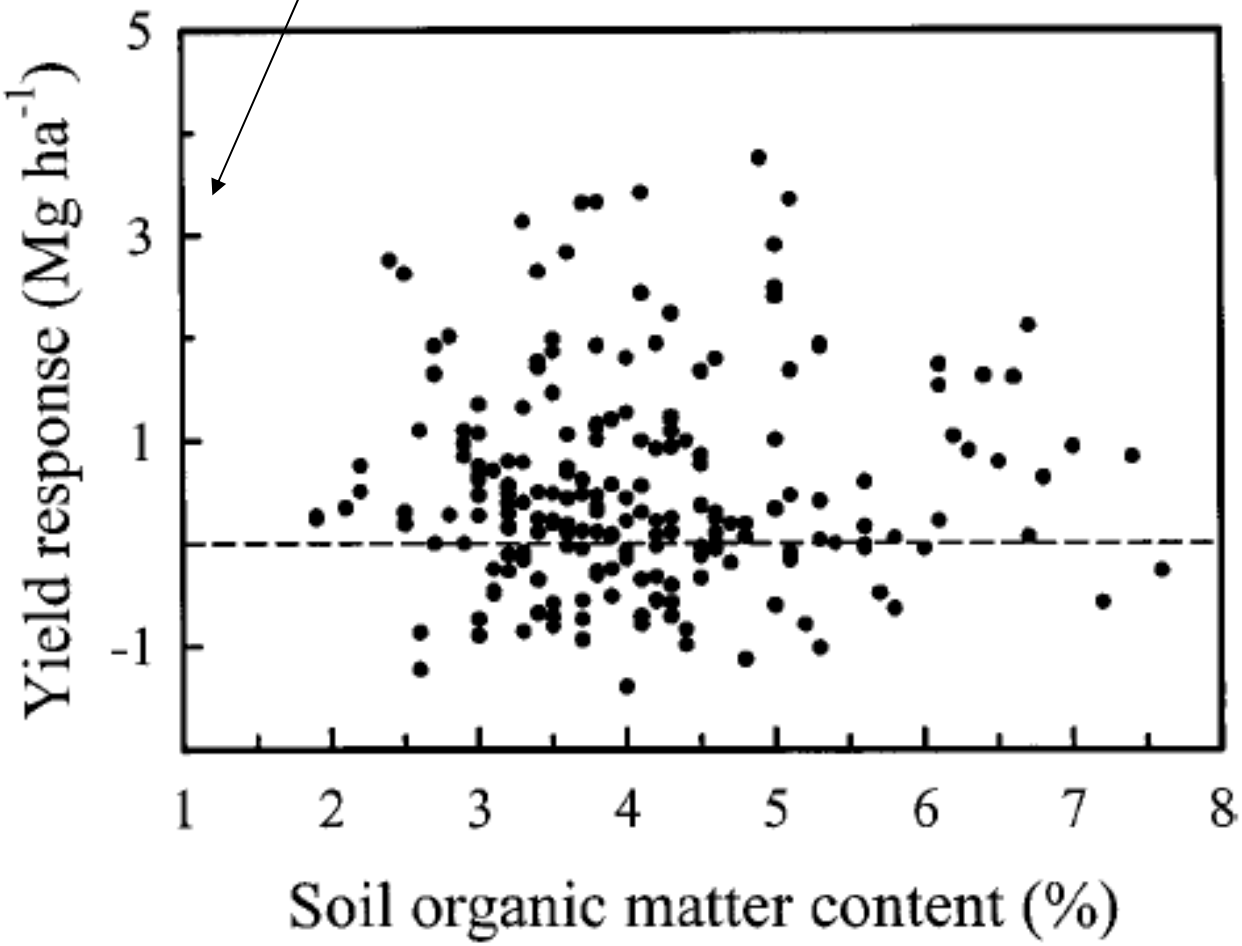


Fig. 7. Relationship between soil organic matter concentrations and corn yield response to fertilizer N applied at 100 kg ha^{-1}.

Soil OM showed no relationship with yield response

Multiple regression analysis showed that simultaneously considering rates of manure-N availability, yield goal, and soil organic matter explained no more than 10% of variability in yield response

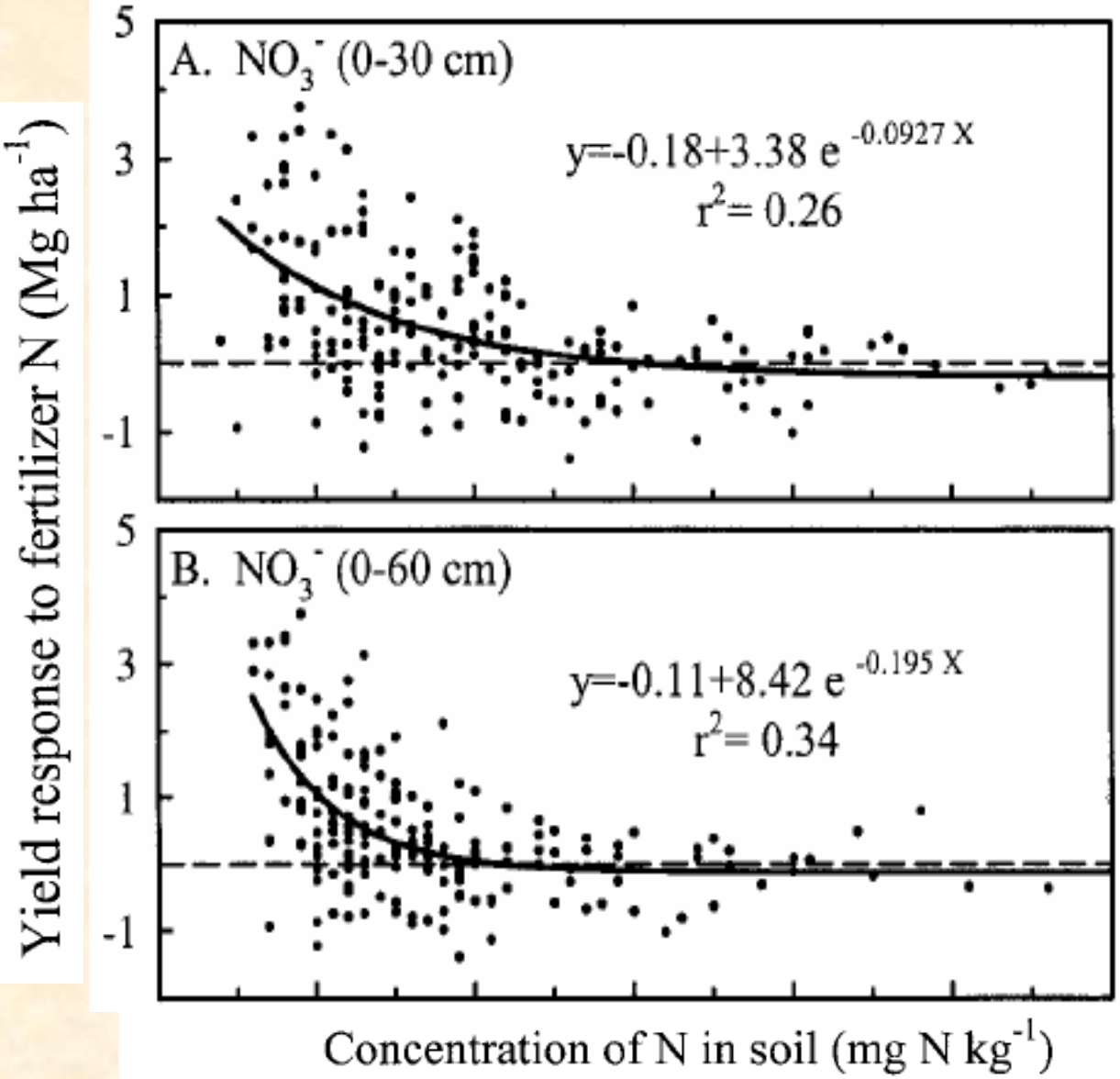


Fig. 1. Relationships between corn yield responses to fertilizer N applied at 100 kg ha^{-1} and concentrations of soil (A) NO_3–N to a depth of 30 cm, (B) NO_3–N to a depth of 60 cm, (C) exchangeable NH_4–N to a depth of 30 cm, and (D) exchangeable NH_4–N and NO_3–N to a depth of 60 cm.

PSNT described 26% of variability in yield response when sampled to 12 inches

PSNT described 34% of variability in yield response when sampled to 2-foot depth

N fertilization by farmers at experimental fields

Manure management

- N fertilization at 37% of the sites would have been profitable
- Mean N rate applied by farmers was 128 lbs N/acre
- Mean increase in yield was 8.2 bu/acre
- Application of 128 lbs N/acre was not profitable

PSNT and N fertilizer needs

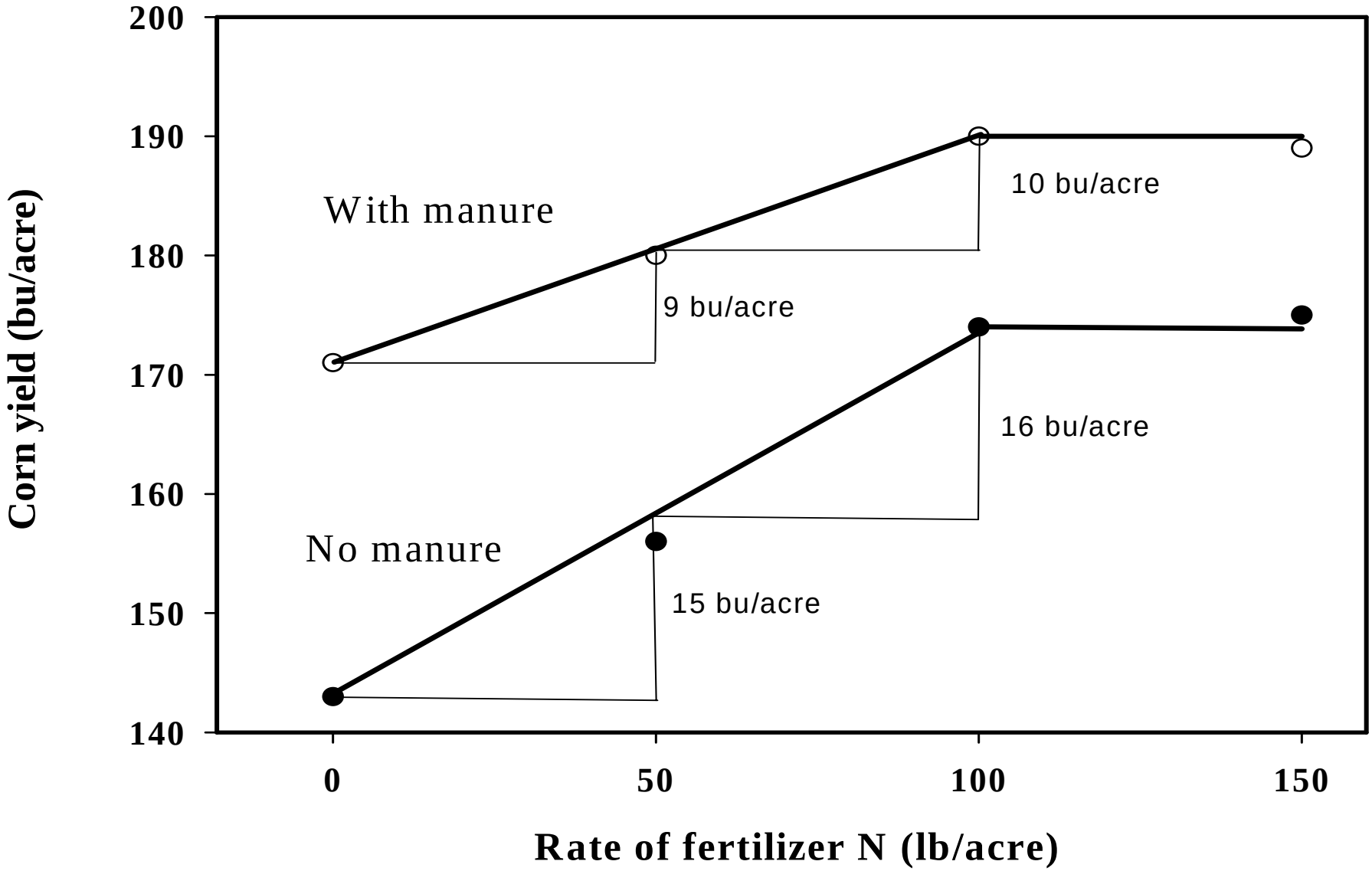
Manure management

- Mean yield response at sites where the PSNT indicated no N fertilizer needed (greater than 20 ppm) was a negative 0.48 bu/acre
- Mean yield response for sites where PSNT indicated a need for N fertilizer (20 ppm or less) was 14.8 bu/acre
- The soil test was a reliable predicator of whether N fertilizer was needed – not the rate of N needed

Conclusions from evaluation of YG system for N recs

Manure management

- Information typically used to estimate N availability from manure not useful to predict how much manure to apply
- Up to 10% of the variability in yield response explained by the YG system
- Difficult to predict N fertilizer needs on manured soils using current recommendation system



Corn on beans; hoop house manure; 160 lbs N/a; 0, 50, 100, 150 lbs liq N; Yield benefit from manure

How make accurate N recommendations?

Manure management

- Can we agree that our current system of making N recommendations isn't adequate?
- I think we could greatly improve our N use efficiency if we agree to use two concepts to guide the development of a new system for N recommendations:
  - N fertilizer recommendations in humid regions will always be a guess
  - Biological concepts should be used to make N recommendations and not engineering concepts

N fertilizer recommendations always a guess

Manure management

- Weather effects, mainly rainfall, will change N use efficiency after application of the N
- Leaching losses main concern
- Denitrification losses also a concern on wetter soils
- Extremely difficult to predict amount of N available from manure applications. Both this year's applications and previous applications.
- Maybe in future will provide N recommendations in terms of probability: 80% chance of needing 75 lbs N/acre

Biological concepts

Manure management

- Need to manage variability by using trend lines
- Need to maintain field-by-field records with time
- Need to have objective evaluation of how well we guessed (stalk nitrate test)

Case Study – Five years of evaluations

Year	Rotation	Fertilizer N		Grain Yield		
		Low Rate	High Rate	Low Rate	High Rate	Diff.
		--------lb N/acre--------		----------bu/acre----------		
2001	C-SB	80	130	176.8	175.6	-1.2
2002	C-SB	70	120	192.5	195.4	2.9
2003	C-C	130	180	166.6	166.2	-0.4
2004	C-SB	60	110	199.7	206.1	6.4
	C-C	110	160	172.0	178.3	6.3
2005	C-SB	60	110	191.8	197.6	5.8
	C-C	110	160	182.1	193.9	11.9

Most important trendline

Manure management

- Cornstalk nitrate values
- In Connecticut our Nutrient Management Plans require use of cornstalk test
- If cornstalk values consistently high, recommend reducing N applications
- Field-by-field objective evaluation of N management with time provides a trendline that can be used to make improved recommendations

Development of new N recommendation system in CT

Manure management

- Farmers' NMPs placed on server at Soil Test Lab
- Field history, PSNT, and CSNT data used to make recommendations
- Will adjust N recommendation each year based on evaluation of last year's guess
- Objective is to have CSNT values in optimum range for all fields

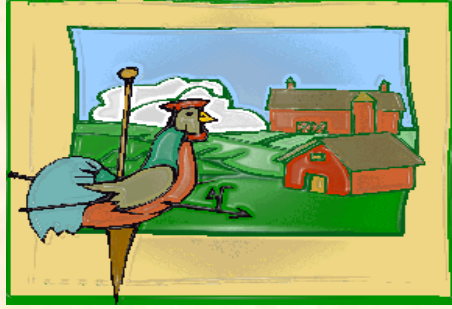
Rates of N to apply before crop emergence when not planning to sidedress N

Crop category	lbs N/acre
Corn on recently manured fields	0-100
Corn after established alfalfa	0-30
2nd year corn after established alfalfa	0-100
Corn after corn (no manure history, no previous alfalfa)	90-180
Corn after grass hay (no manure)	60-150
Corn (with no other information)	0-180

Rates of N to apply preplant when planning to sidedress N using the PSNT

Crop category	lbs N/acre
Corn on recently manured fields	0-30
Corn after established alfalfa	0-30
2nd year corn after established alfalfa	0-30

How use field records to make N recs?



Manure management

- Two levels: state and farm
- State: I use statewide data to look for categories of management practices that consistently produce high or low CSNT values
- Some categories of interest: 1) Corn silage/rye silage rotation = many CSNT values less than 250 ppm; 2) fields irrigated with liquid manure = many CSNT values > 8,000 ppm; 3) application of layer chicken manure > 5 ton/acre with high soil test P = many CNST values > 8,000 ppm

How use field records to make N recs?

Manure management

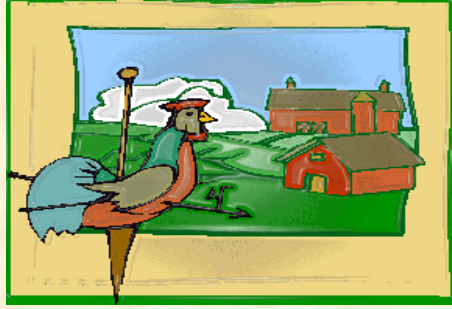
- **Farm level:** Manured field and farmer applies 50 lb N/acre and CSNT results are greater than 8,000 ppm; year 2 recommendation of 0 to 50 lb N/acre is made with the note that 0 lb N should be applied unless the farmer has information that indicates a greater or lesser amount is needed.
- In the second year if the farmer applies 0 N and the CSNT value is greater than 6,000 ppm, then the year 3 recommendation is 0 N. In subsequent years, the recommendation is 0 N unless the CNST value is less than 250 ppm.

Point vs nonpoint pollution

Manure management

- Engineering approach that worked well to reduce point-source pollution, will not work well with nonpoint pollution
- Need regulations that are performance based with objective criteria
- Need regulations that have targets for the entire biological system (farm)
- Example: in five years 50% of cornstalk values should be in optimum range with no value greater than 6,000 ppm

Conclusions



Manure management

- Need field-by-field records to manage N
- Need cornstalk nitrate results to put fields in categories of response (need better post-mortem tests)
- NMPs should be interactive so can summarize important data over years
- Should use field records to improve recommendations
- Regulations should be based on objective measurements of performance with targets for proper management, e.g., submit CSNT values showing no fields greater than 6,000 and 50% of fields in optimum range