IS THE CORN-SOYBEAN ROTATION IN TROUBLE?

EVIDENCE FROM THE LANCASTER ROTATION EXPERIMENT

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Overview

- **Crop Rotation Research**
  - ✓ “Black box” of agronomy
  - ✓ What is our understanding?
- **Long-term Cropping Systems “The Lancaster Experiment”**
  - ✓ Is corn grain yield changing with time?
  - ✓ Can crop systems improve (or deteriorate) over time?
- **Economics?**

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Crop Rotation Research – The Rotation Effect – What is it?

- **Crop Rotation**
  - ✓ Universal management practice
  - ✓ Proven management decision that increases crop yields
  - ✓ Currently, increased economic benefit for monoculture
- **Rotation Effect**
  - ✓ Additional benefit of rotating crops
    - ❑ production inputs optimized
    - ❑ problems associated with monoculture are not apparent.

  - ✓ The effect of all conditions, other than N, supplied by legumes in a rotation (Baldock et al. 1991)
  - ✓ Other non-legume crops can provide benefits as well (Robinson, 1966; Langer and Randall, 1981; Crookston et al., 1988)

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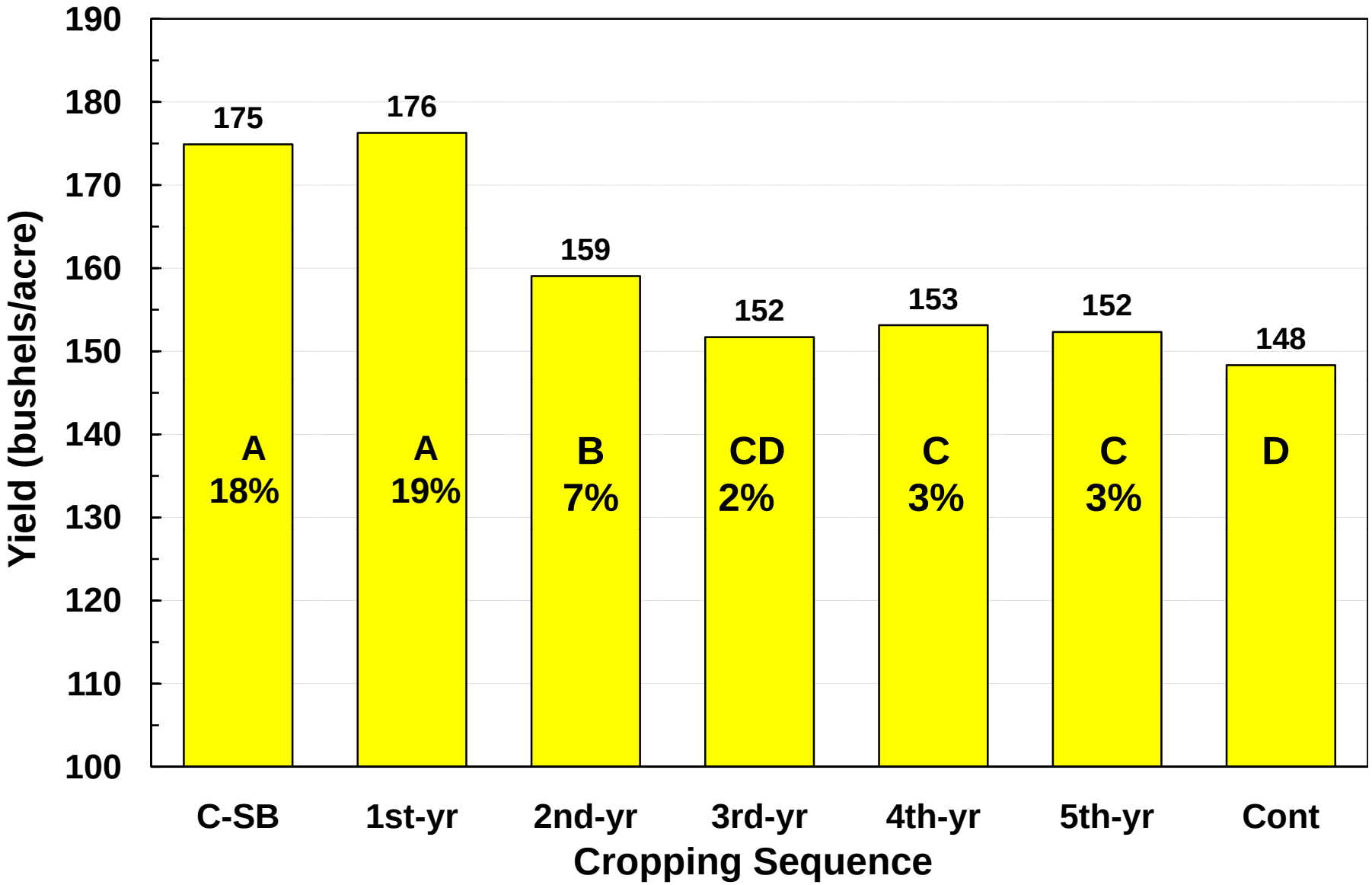
Corn Yield Response Following Five Years of Soybean (Arlington, WI; 1987 to 2005; Control Treatments)



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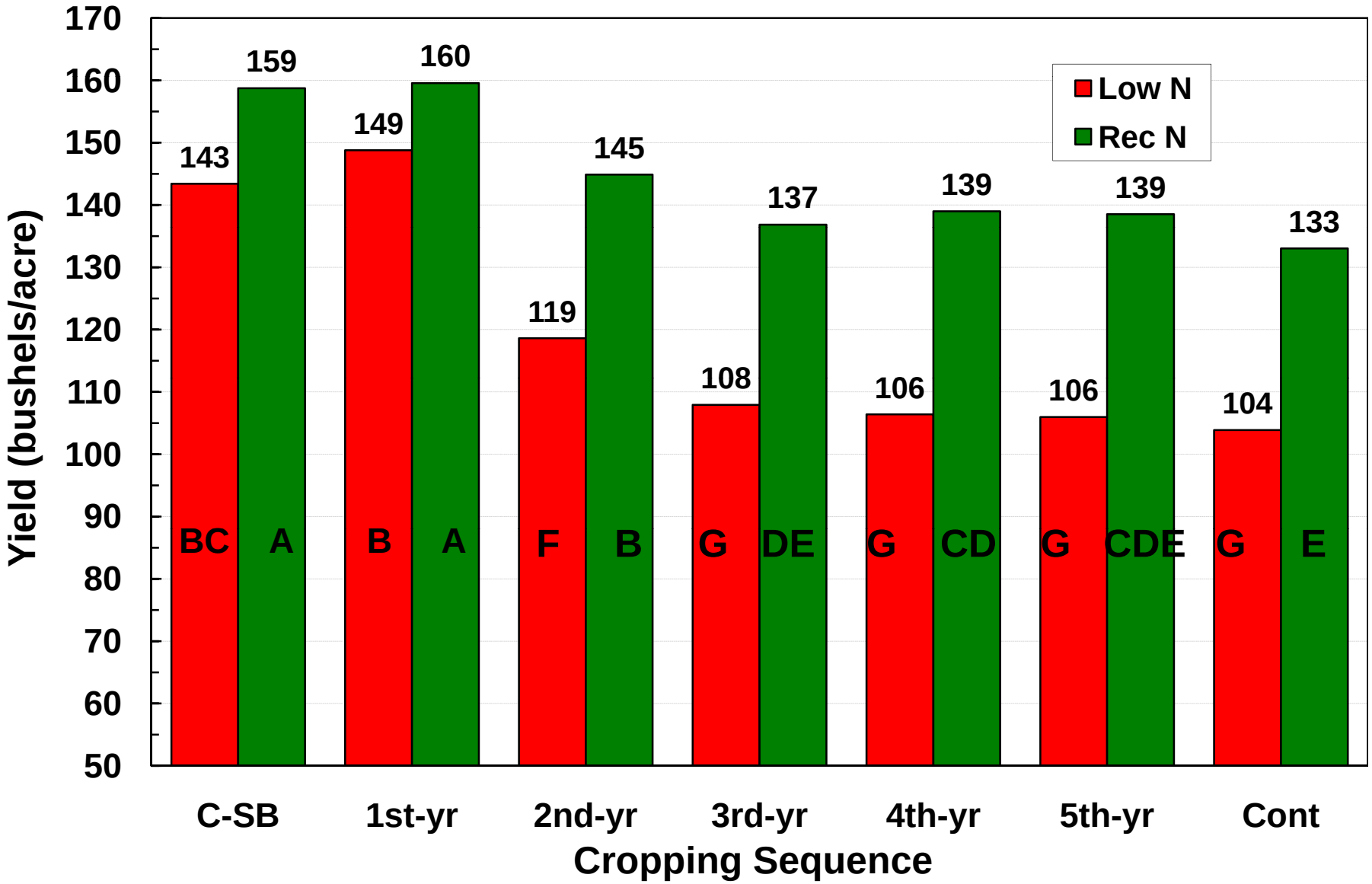
Corn Yield Response to N Following Five Years of Soybean
(Arlington, WI; 1987 to 1994; Average of Tillage Treatments)



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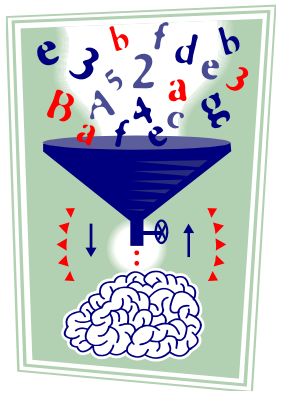
Crop Rotation Research – What Have We Learned?



- **1st Century B.C.: Varro recognized rotation effect improved crop production (Baldock et al., 1981)**
- **Pre 1950s: Farmers recognized the importance of rotation because of few options for fertility and pest management**
- **1950s and 60s: Practice of corn and soybean monoculture became popular**
  - ✓ Chemical fertilizers and pesticides
  - ✓ Rotation effect though to be N related
- **1970s: Recognition that all rotation effects could not be overcome.**
  - ✓ Allelopathic effects from weeds (Bhowmik and Doll, 1984)
  - ✓ Separation of N effects and non-N effects (Baldock et al., 1981)

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Crop Rotation Research – What Have We Learned?

- **1980s: What does crop rotation do in the system?**
  - ✓ Improve soil moisture (Roder et al., 1989)
  - ✓ Improve soil structure (Dick and Van Doren, 1985; Griffith et al., 1986)
  - ✓ Increases beneficial soil microbes (Cook, 1984)
  - ✓ Decreases pests (Cook, 1984; Dabney et al., 1988)
  - ✓ Decreases phytotoxic compounds from crop residues (Yackle and Cruse, 1984)
- **1990s: Series of experiments to eliminate factors**
  - ✓ Above-ground residue has no effect (Crookston and Kurle, 1989)
  - ✓ Host-specific pathogens do not account for the rotation effect (Whiting and Crookston, 1993)
  - ✓ Root development differences observed (Nickel et al., 1995)
  - ✓ Management recommendations provided and rotation effect better quantified (Meese et al., 1991; Porter et al., 1997, 1998; and many more)
- **2000s: Serious questions about sustainability in monoculture and two crop rotations**
  - ✓ Use long-term crop rotation experiments

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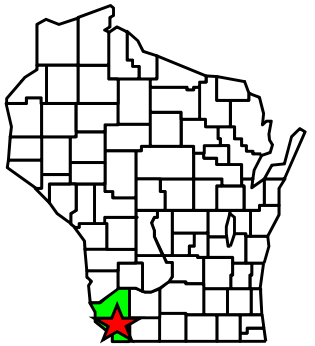
The Lancaster Rotation Experiment
A Long-Term Cropping System Study

- **A multiple crop rotation experiment established in 1966**
- **Objective: To compare the benefits of growing corn continuously and in rotation using commercial nitrogen fertilizer.**
- **RCB in a split-plot arrangement with two replications.**
  - ✓ Main-plots= 21 rotations
  - ✓ Split-plots= four N levels in corn



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Rotation History of the Lancaster Rotation Experiment

Year of change	Rotations	Corn N rates (lbs N A^{-1})
1966	CC CSCOaA CCCOaA CCOaAA COaAAA	0, 75, 150, & 300
1977	CC CSCOaA CCCAA CCOaAA CCAA AA	0, 50, 100, & 200
1987	CC CSCOaA CCCAA CCOaAA CS CA AA	0, 50, 100, & 200
2005	CC CSCOaA CCCAA CCOaAA CS CSW	0, 50, 100, & 200

- C, Corn; S, Soybean; Oa, Oat with alfalfa seeding; A, Alfalfa; W, Wheat
- C, first phase; C, second phase; C, third phase

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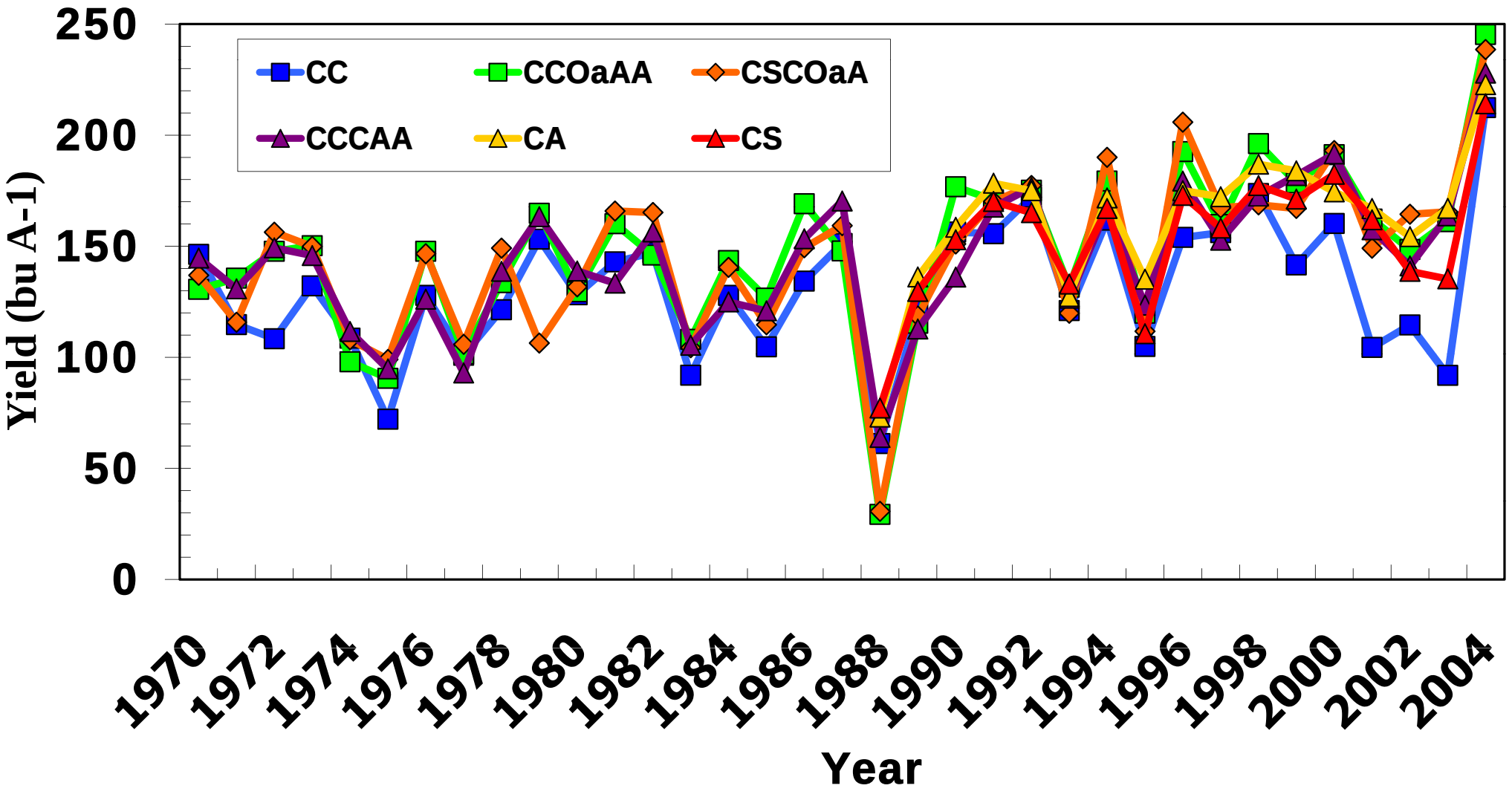
Corn Yields in the Lancaster Rotation Experiment (Analysis over time: 1970-2004)



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Analysis over Time and Space (2-yr and 5-yr Cycles)

Cycle	CC	Cycle	CS		Cycle	CSCOaA				
1	C	1	C	S	1	C	S	C	Oa	A
2	C	1	S	C	1	A	C	S	C	Oa
3	C	2	C	S	1	Oa	A	C	S	C
4	C	2	S	C	1	C	Oa	A	C	S
5	C	3	C	S	1	S	C	Oa	A	C

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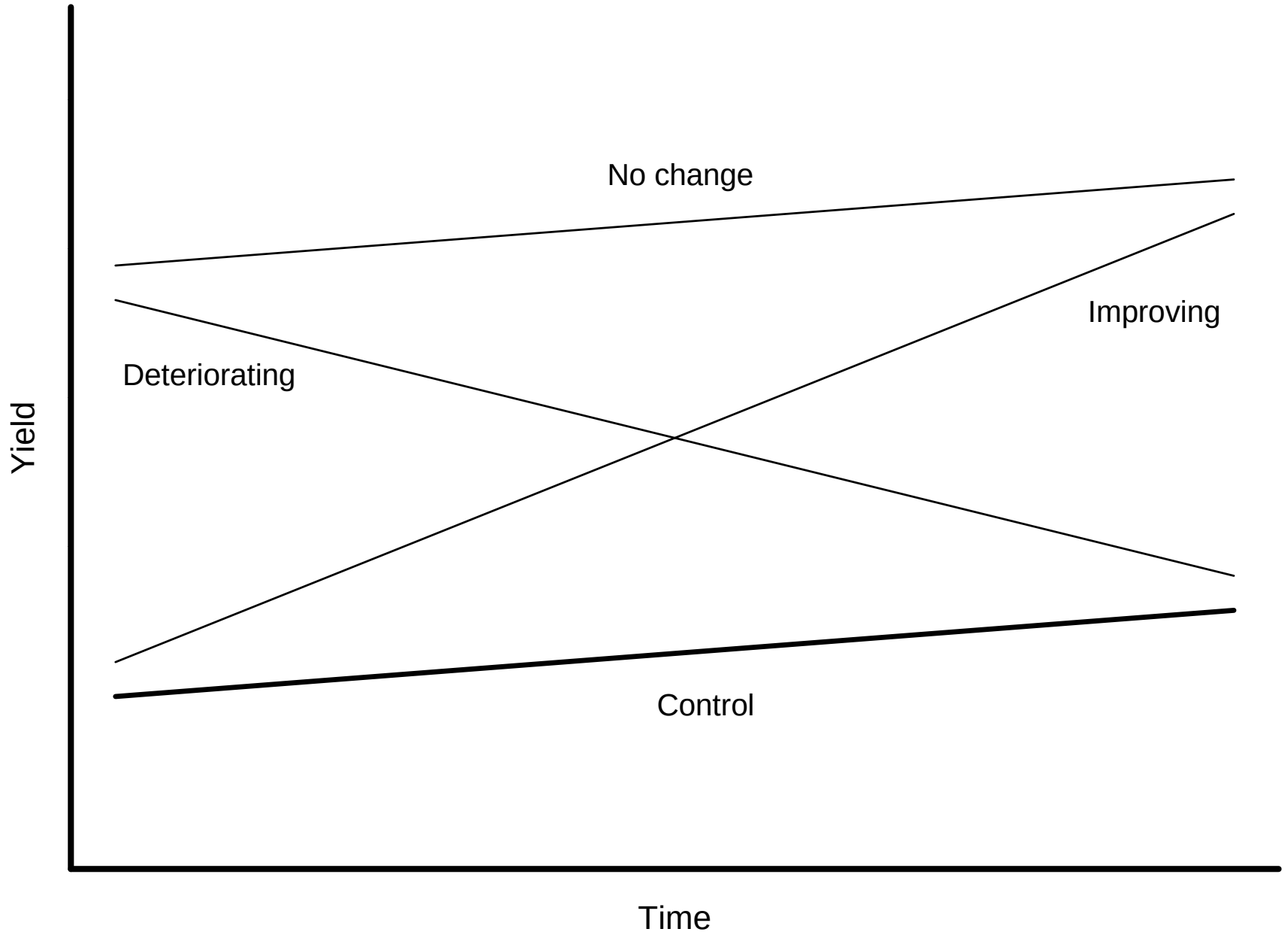
What are we looking for?
How can we tell whether a cropping system is changing?



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Is Corn Grain Yield Changing? (Is there a slope?)

First Corn Phase in 5-yr Cycles (1970 – 2004; 7 Cycles)

	N rate (lb N A^{-1})			
Rotation	**0**	**50**	**100**	**200**
		bu A^{-1} yr^{-1}		
CC	**NS**	**NS**	**NS**	**†**
***C*CCAA**	**1.2****	**1.1****	**1.4****	**1.6****
***C*COaAA**	**1.3****	**1.2****	**1.5****	**1.6*****
***C*SCOaA**	**1.2****	**1.1****	**1.4*****	**1.6*****

†, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 levels

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Is Corn Grain Yield Changing? (Is there a slope?)

Second Corn Phase in 5-yr Cycles (1970 – 2004; 7 Cycles)

	N rate (lb N A^{-1})			
Rotation	**0**	**50**	**100**	**200**
			bu A^{-1} yr^{-1}	
CC	NS	NS	NS	†
CCCAA	NS	NS	NS	1.0*
CCOaAA	NS	NS	†	1.1*
CSCOaA	NS	NS	0.9*	1.2**

†, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 levels

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Is Corn Grain Yield Changing? (Is there a slope?)
Third Corn Phase in 5-yr Cycles (1970 – 2004; 7 Cycles)

	N rate (lb N A^{-1})			
Rotation	**0**	**50**	**100**	**200**
		bu A^{-1} yr^{-1}		
CC	**NS**	**NS**	**NS**	**0.9***
CC*C*AA	**NS**	**NS**	**NS**	**0.9****

†, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 levels

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Is Corn Grain Yield Changing? (Is there a slope?)

Corn in 2-yr Cycles (1989 – 2004; 8 Cycles)

	N rate (lb N A^{-1})			
Rotation	**0**	**50**	**100**	**200**
		bu A^{-1} yr^{-1}		
CC	**NS**	**NS**	**NS**	**NS**
CA	**†**	**NS**	**NS**	**NS**
CS	**-3.0***	**NS**	**NS**	**NS**

†, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 levels

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Are Rotations Improving or Deteriorating?
(Do slopes diverge or converge?)
5-yr vs. 2-yr Rotations in 5-yr Cycles (1990 – 2004; 3 Cycles)

	N rate (lb N A^{-1})			
Rotation	**0**	**50**	**100**	**200**
	bu A^{-1} yr^{-1}			
CC vs. CA	-3.8***	NS	NS	NS
CC vs. CS	-4.1***	NS	NS	NS
CC vs. *C*CCAA	NS	NS	2.5*	2.6*
CC vs. *C*COaAA	NS	NS	NS	NS
CC vs. *C*SCOaA	NS	NS	NS	2.5*
CA vs. CS	NS	NS	NS	NS
CA vs. *C*CCAA	3.0***	NS	NS	NS
CA vs. *C*COaAA	2.7*	†	NS	NS
CA vs. *C*SCOaA	2.7*	NS	NS	NS
CS vs. *C*CCAA	3.3***	2.5*	NS	NS
CS vs. *C*COaAA	3.0***	2.7*	NS	NS
CS vs. *C*SCOaA	2.9***	NS	NS	NS

†, *, **, *** Significant at the 0.10, 0.05, 0.01, and 0.001 levels

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Conclusions

- **Corn grain yield of extended (5-yr) rotations increase at a greater rate over time than 2-yr rotations and CC.**
- **Nitrogen plays a major role in maintaining and improving corn grain yields in the absence of crop rotation.**
- **Extended rotations involving forage crops may be more sustainable than current short-term agricultural practices, because time (>2 yr) along with rotation and nitrogen were required to improve corn grain yields.**

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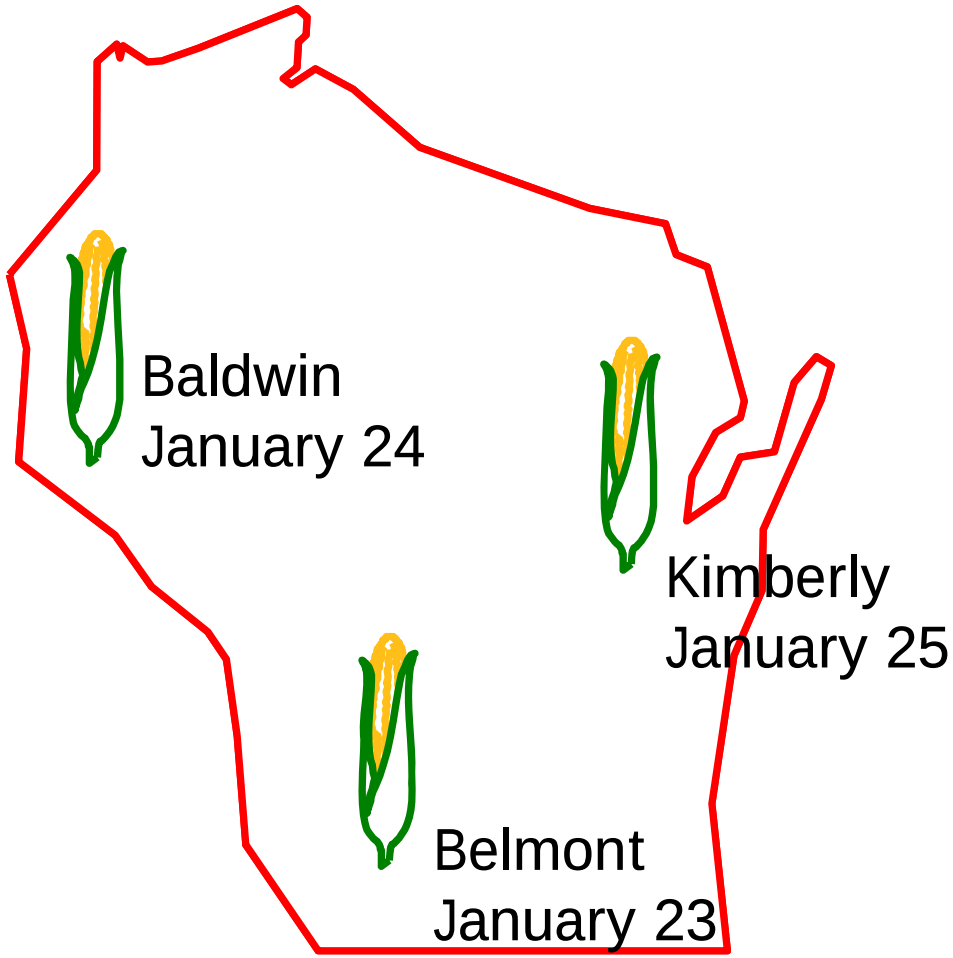
Thanks for your attention!
Questions?

2007 Corn Conferences



WISCONSIN Corn/Soy EXPO

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February 1-2, 2007
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