

IS THE CORN-SOYBEAN ROTATION IN TROUBLE?

EVIDENCE FROM THE LANCASTER ROTATION EXPERIMENT

Joe Lauer and Trent Stanger
University of Wisconsin

**Wisconsin Fertilizer, Ag Lime and Pesticide
Management Conference**
January 18, 2007



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?**



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

- **Crop Rotation**

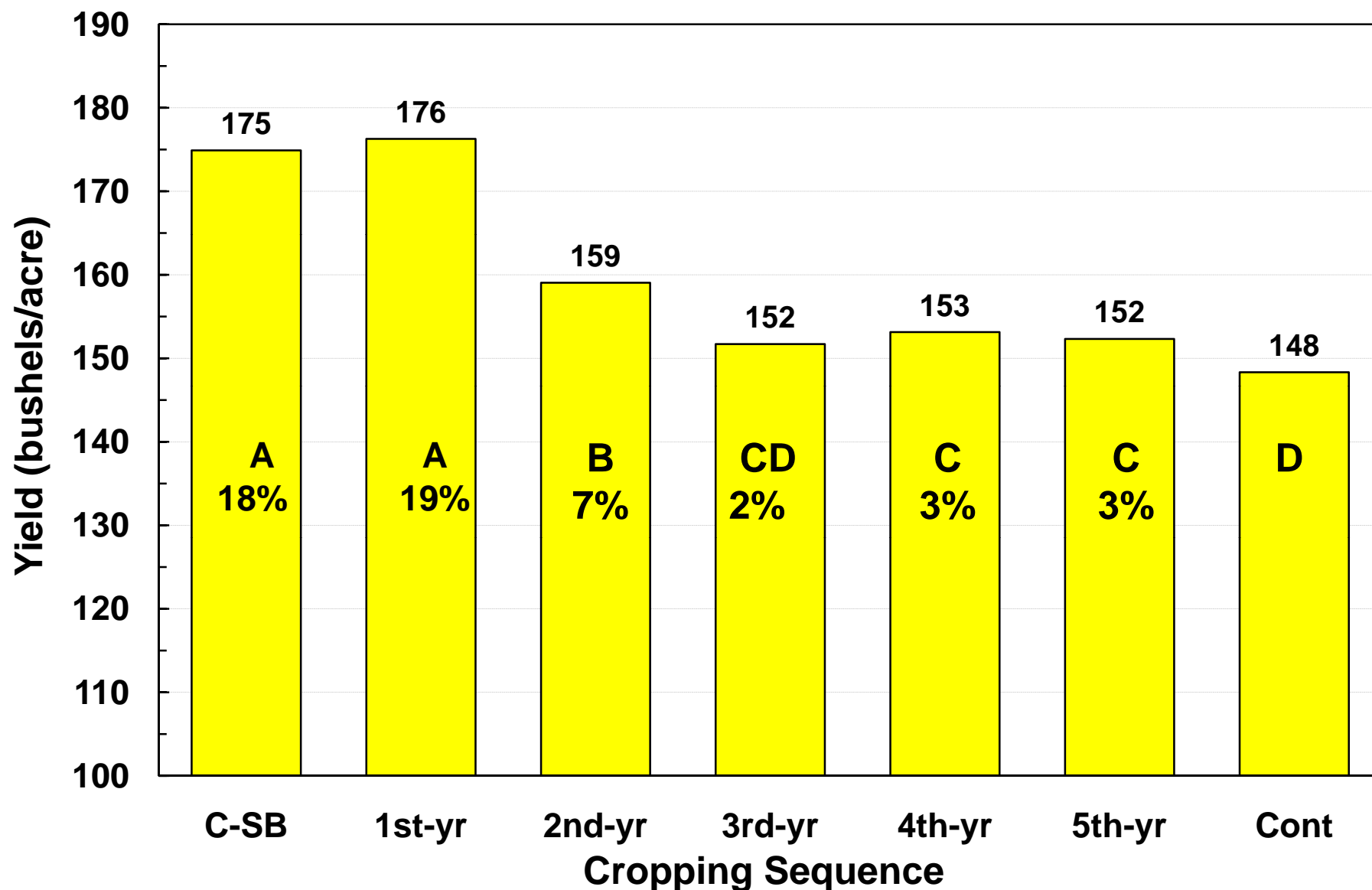
- ✓ Universal management practice
- ✓ Proven management decision that increases crop yields
- ✓ Currently, increased economic benefit for monoculture

- **Rotation Effect**

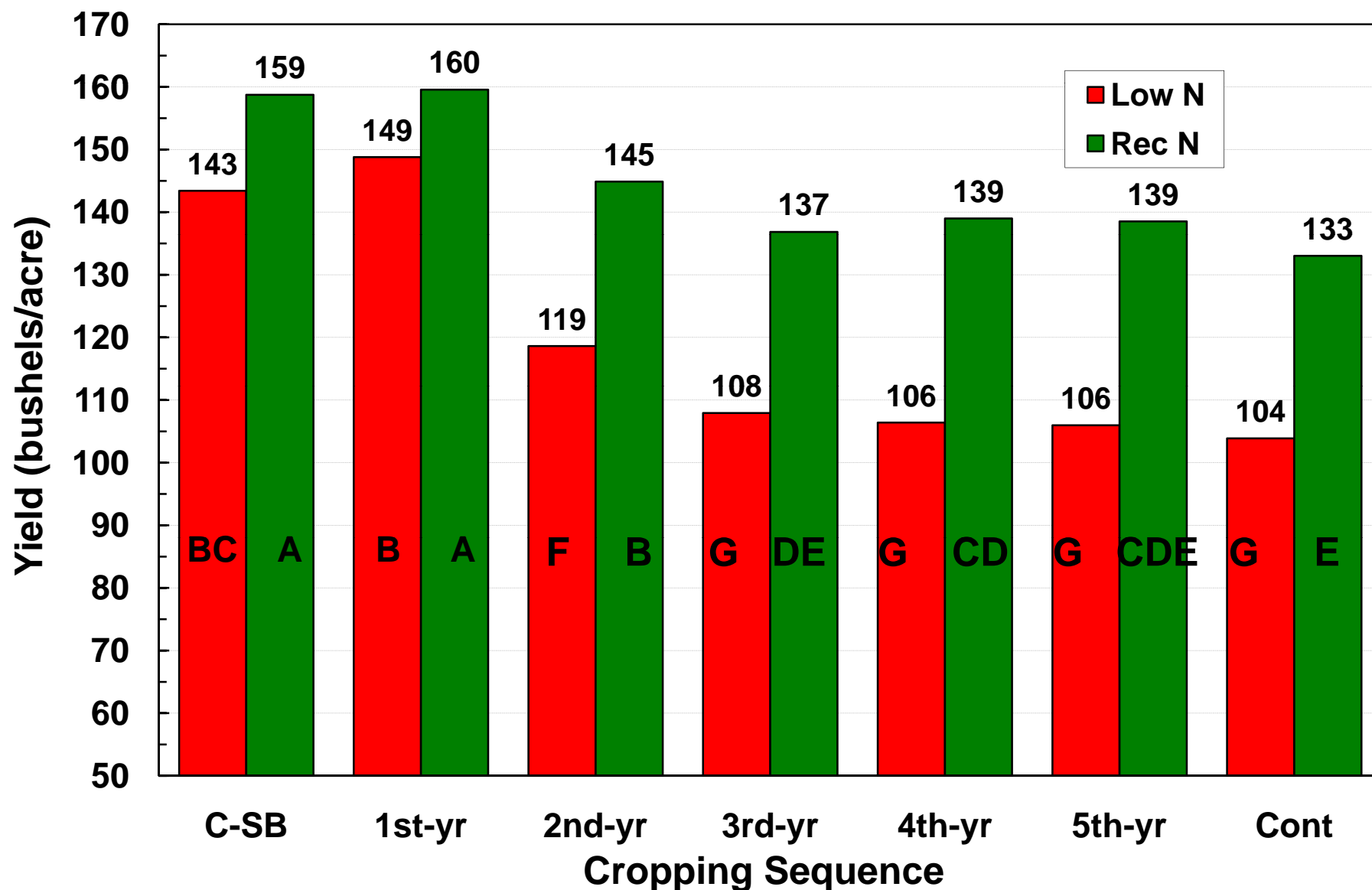
- ✓ Additional benefit of rotating crops
 - ❑ production inputs optimized
 - ❑ problems associated with monoculture are not apparent.
- ✓ The effect of all conditions, other than N, supplied by legumes in a rotation (Baldock et al. 1991)
- ✓ Other non-legume crops can provide benefits as well (Robinson, 1966; Langer and Randall, 1981; Crookston et al., 1988)



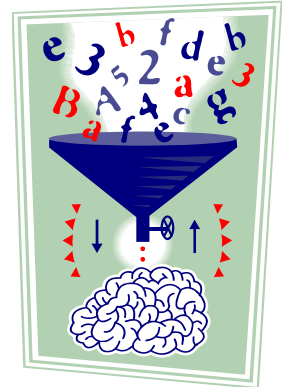
Corn Yield Response Following Five Years of Soybean (Arlington, WI; 1987 to 2005; Control Treatments)



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



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 thought 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)

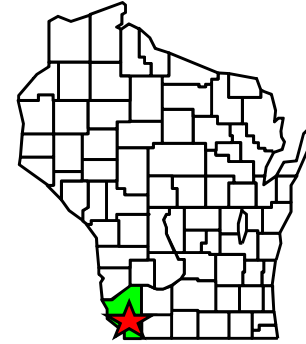
Crop Rotation Research – What Have We Learned?

- **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

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

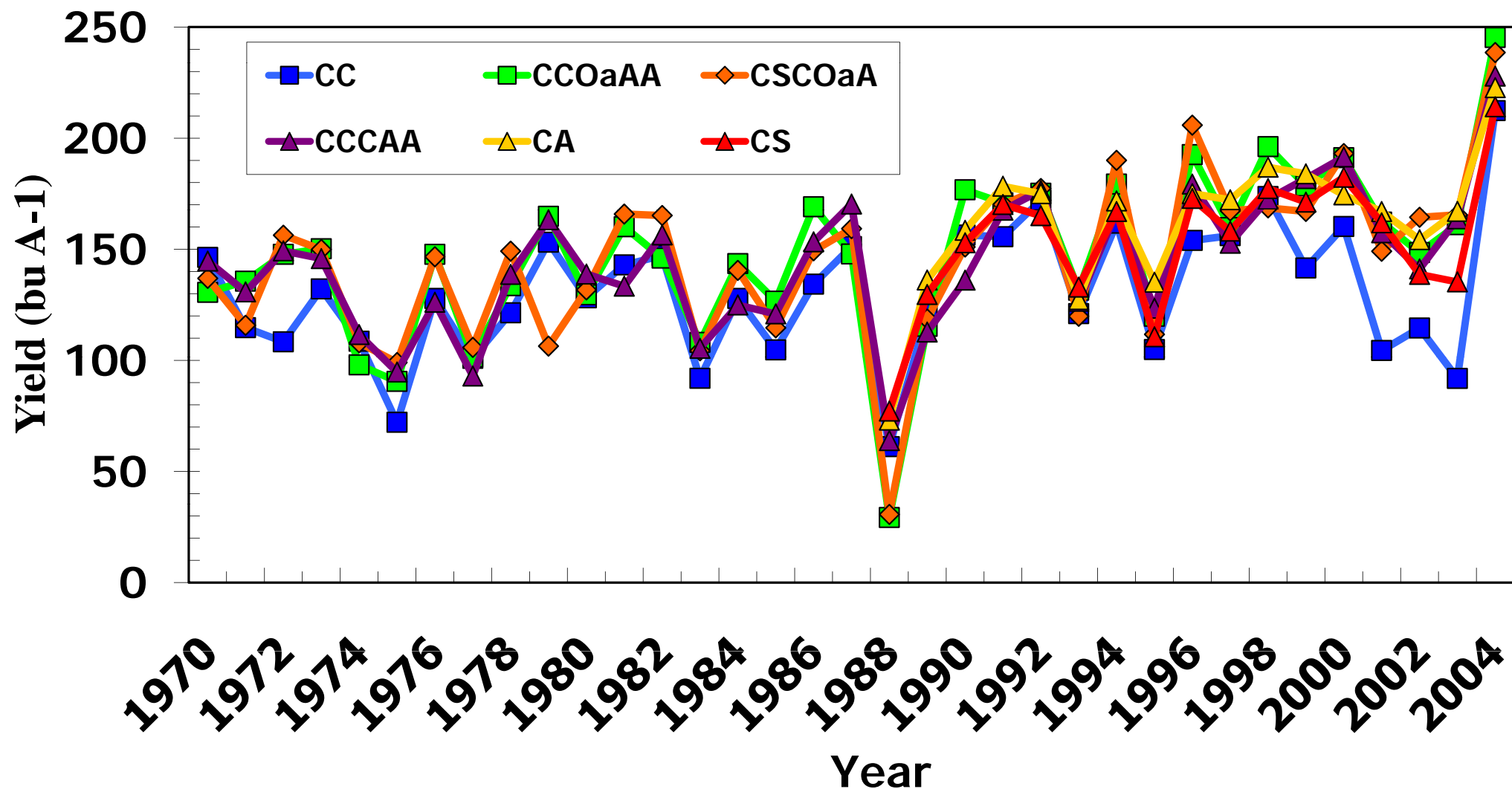


Rotation History of the Lancaster Rotation Experiment

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

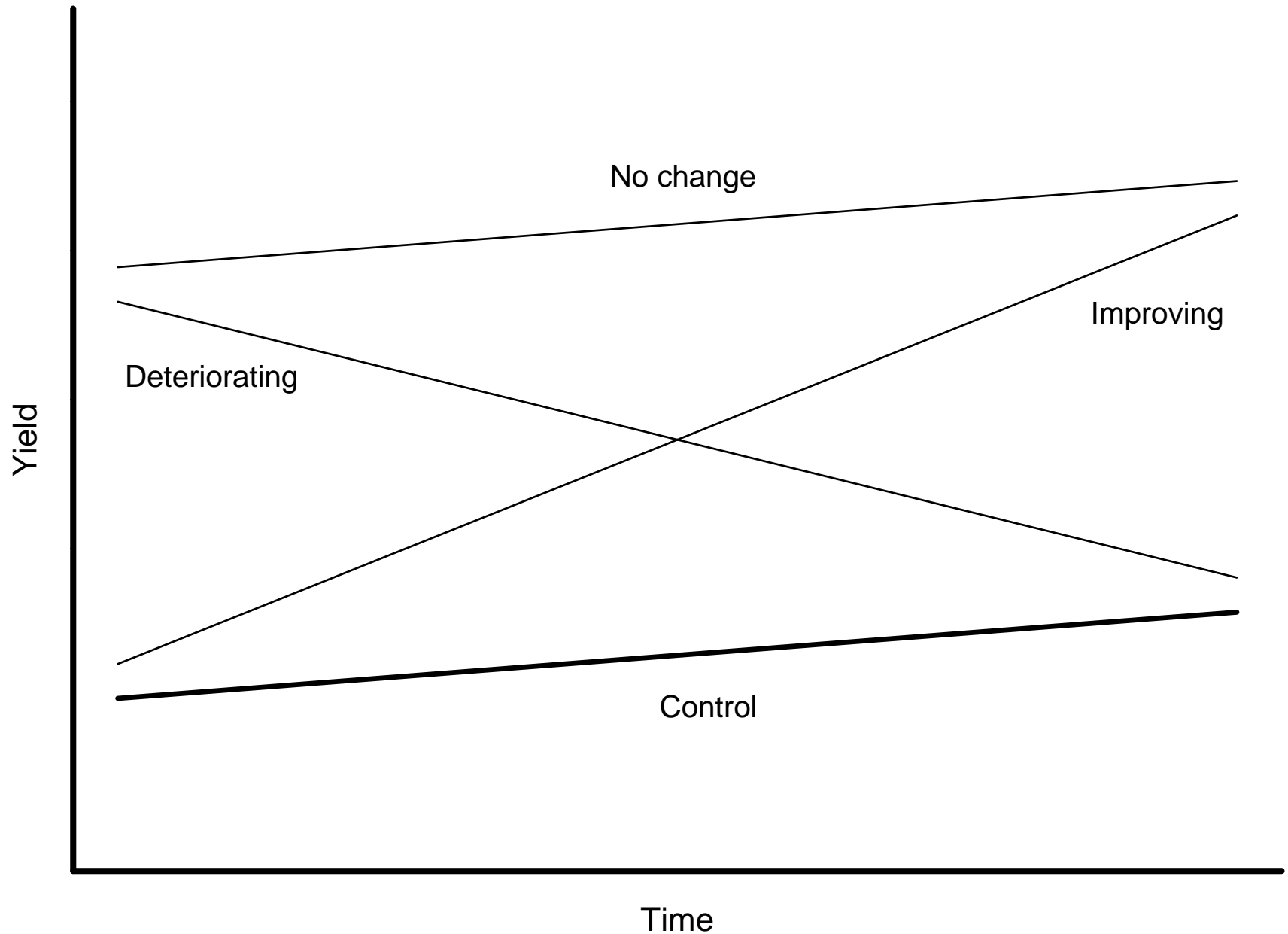
Corn Yields in the Lancaster Rotation Experiment (Analysis over time: 1970-2004)



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

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



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

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

Rotation	N rate (lb N A ⁻¹)			
	0	50	100	200
	<u>bu A⁻¹ yr⁻¹</u>			
CC	NS	NS	NS	†
<i>C</i> CCAA	1.2**	1.1**	1.4**	1.6**
<i>C</i> COaAA	1.3**	1.2**	1.5**	1.6***
<i>C</i> SCOaA	1.2**	1.1**	1.4***	1.6***

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

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

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

Rotation	N rate (lb N A ⁻¹)			
	0	50	100	200
	<u>bu A⁻¹ yr⁻¹</u>			
CC	NS	NS	NS	†
C C CAA	NS	NS	NS	1.0*
C C OaAA	NS	NS	†	1.1*
CS C OaA	NS	NS	0.9*	1.2**

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

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

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

Rotation	N rate (lb N A ⁻¹)			
	0	50	100	200
	<u>bu A⁻¹ yr⁻¹</u>			
CC	NS	NS	NS	0.9*
CCCAA	NS	NS	NS	0.9**

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

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

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

Rotation	N rate (lb N A ⁻¹)			
	0	50	100	200
	<u>bu A⁻¹ yr⁻¹</u>			
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

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

Rotation	N rate (lb N A ⁻¹)			
	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

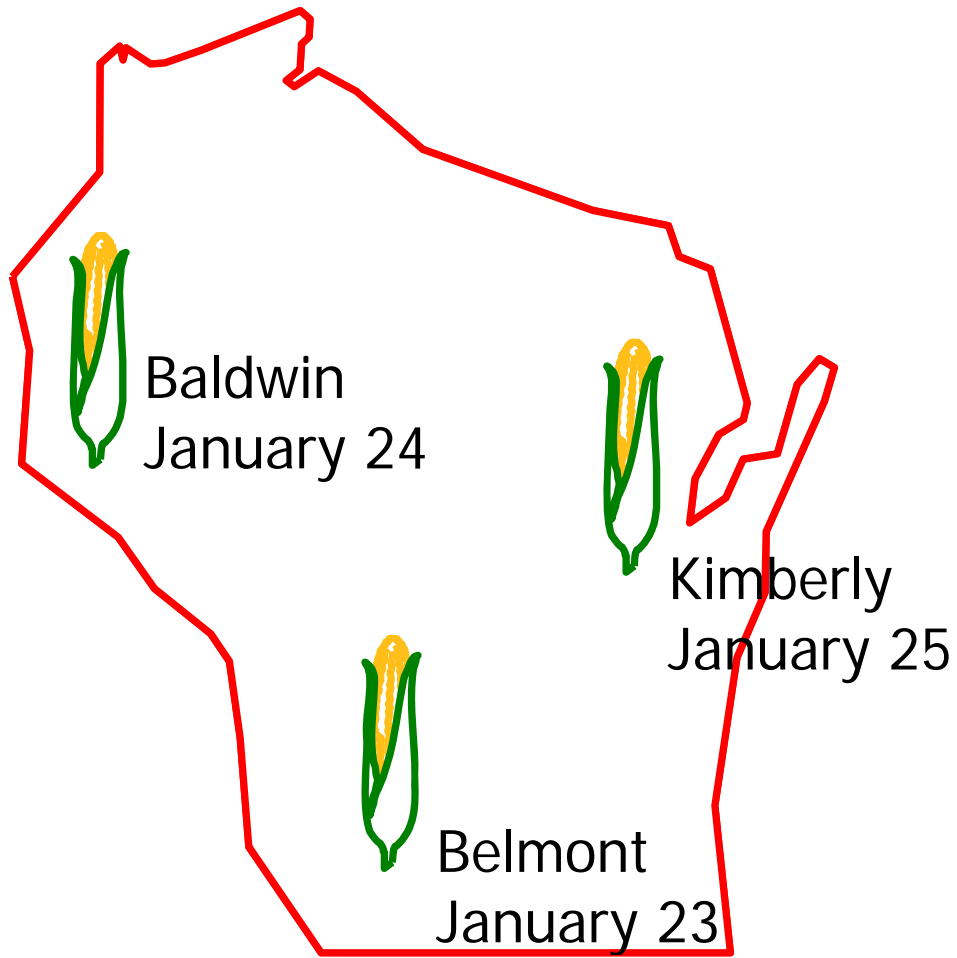
Conclusions

- **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.**



Thanks for your attention!
Questions?

2007 Corn Conferences



WISCONSIN
Corn/Soy
EXPO



PEPS

**February 1-2, 2007
Kalahari Resort
Wisconsin Dells, WI**