The Effect of Various Tillage Operations on Nutrient Availability

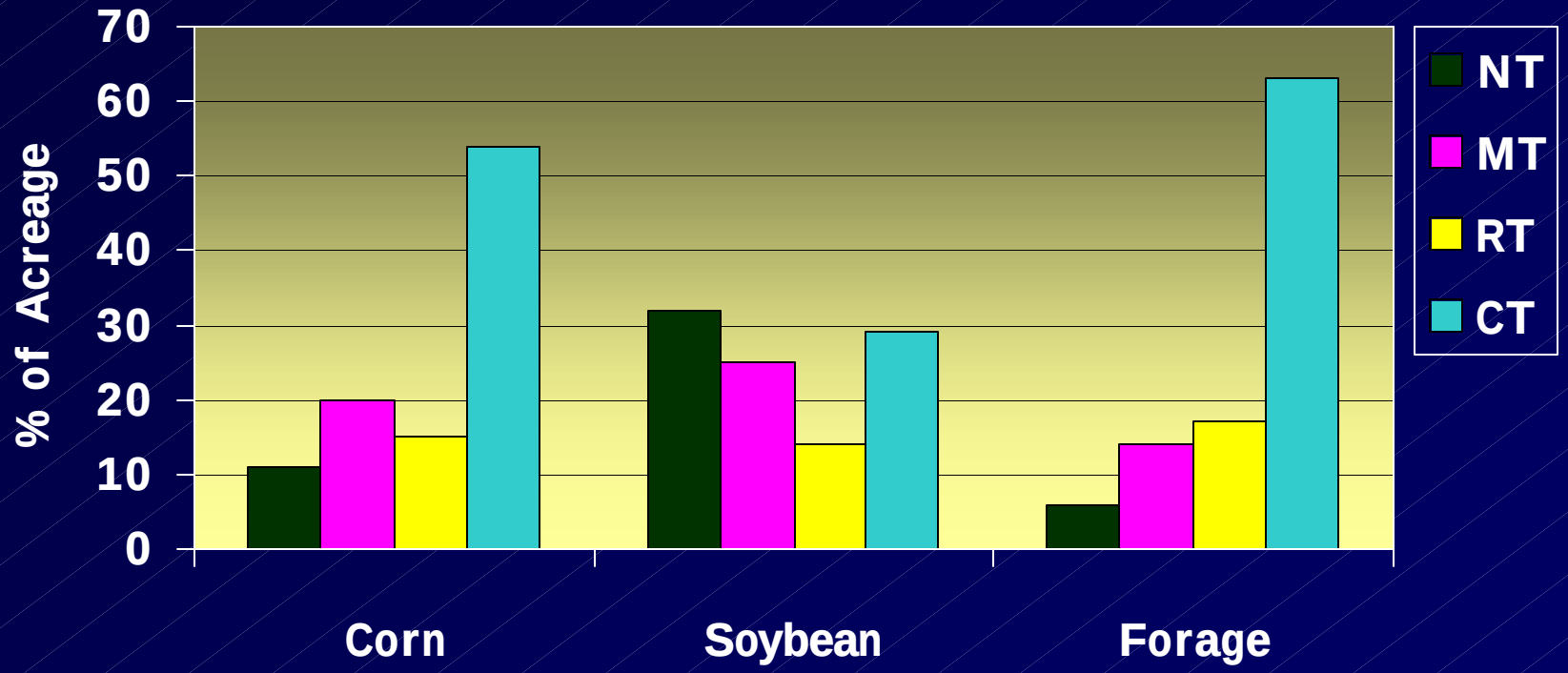
Dick Wolkowski
Department of Soil Science
UW-Madison

Regional trend for more CT

- Eight Midwestern states:
  - 106 million acres of cropland
  - 37 percent of all U.S. cropland
- 46% of no-till acres in U.S. in the Midwest
- 2002 Midwest data
  - 17 million acres of no-till soybeans
  - 7 million acres of no-till corn
  - Forty-five million acres (42.5 %) used conservation tillage

CTIC Website (2002 data)

Wisconsin behind regional trend



CTIC Website (2002 data)

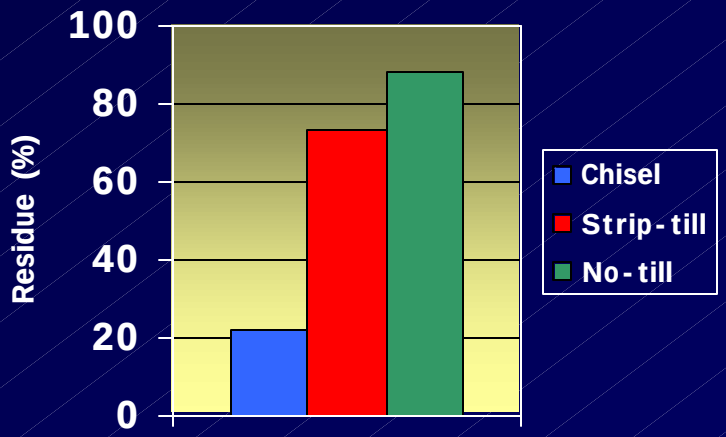
Tillage has a measurable effect on the soil condition

Direct or interactive effects

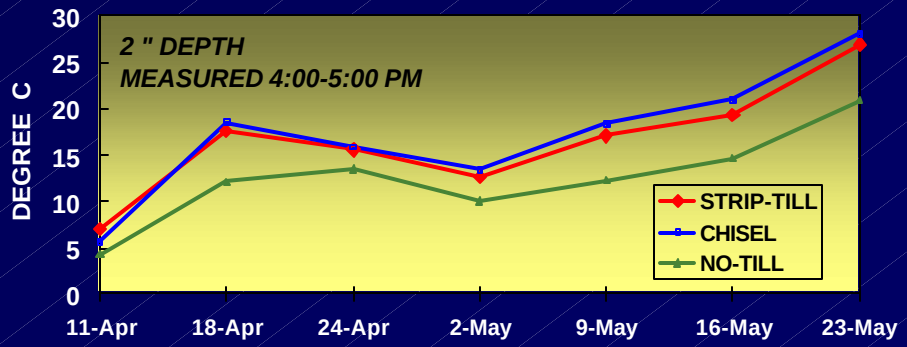
- Physical
  - Residue modifies temperature and moisture
  - Consolidation vs. loosening
- Chemical
  - Nutrient and pH stratification
- Biological
  - C distribution
  - N transformations

Soil temperature affected by tillage and crop residue

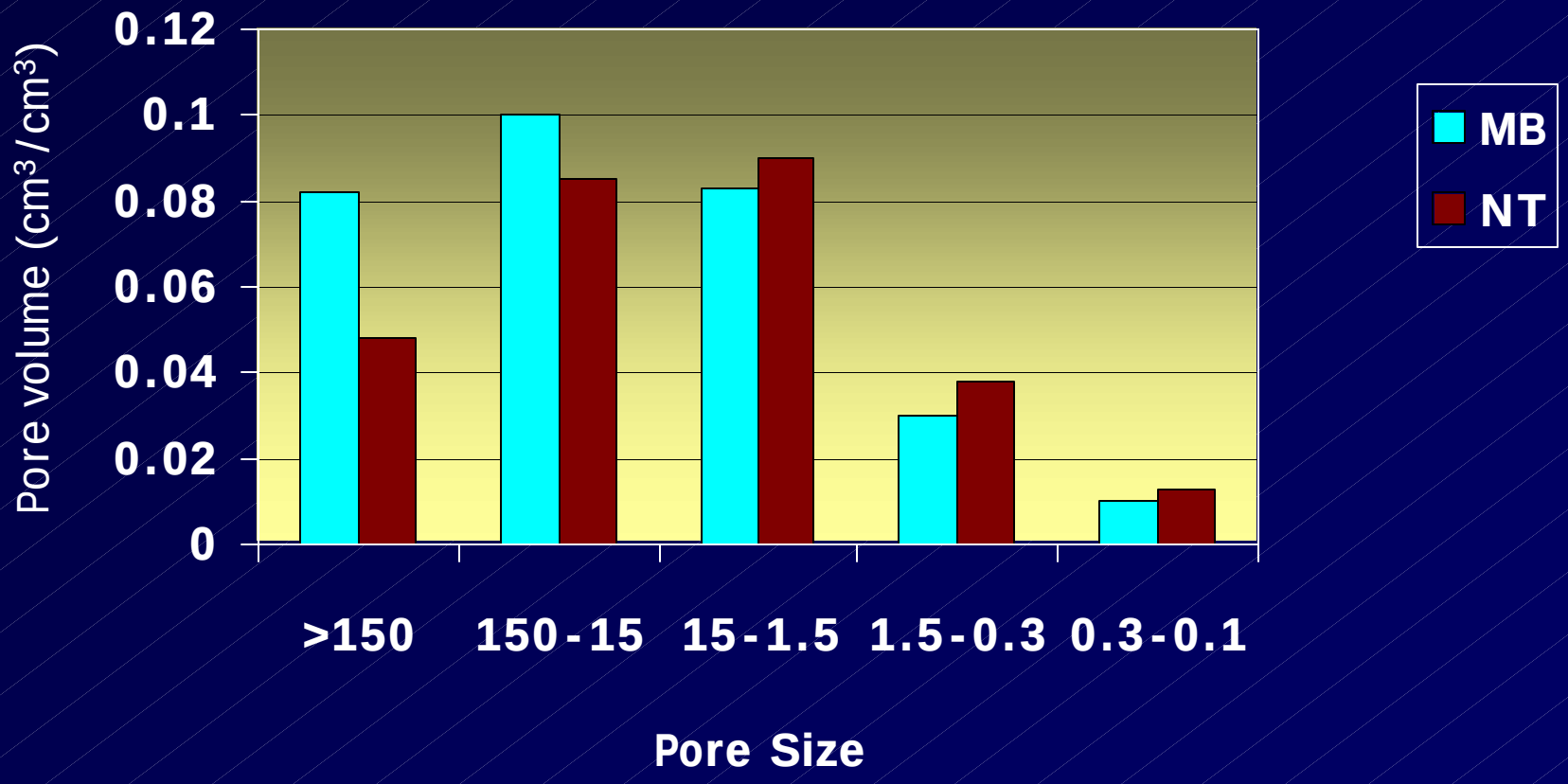
Effect on crop residue, Arlington, 1994



Effect on in-row soil temperature, Arlington, 1994

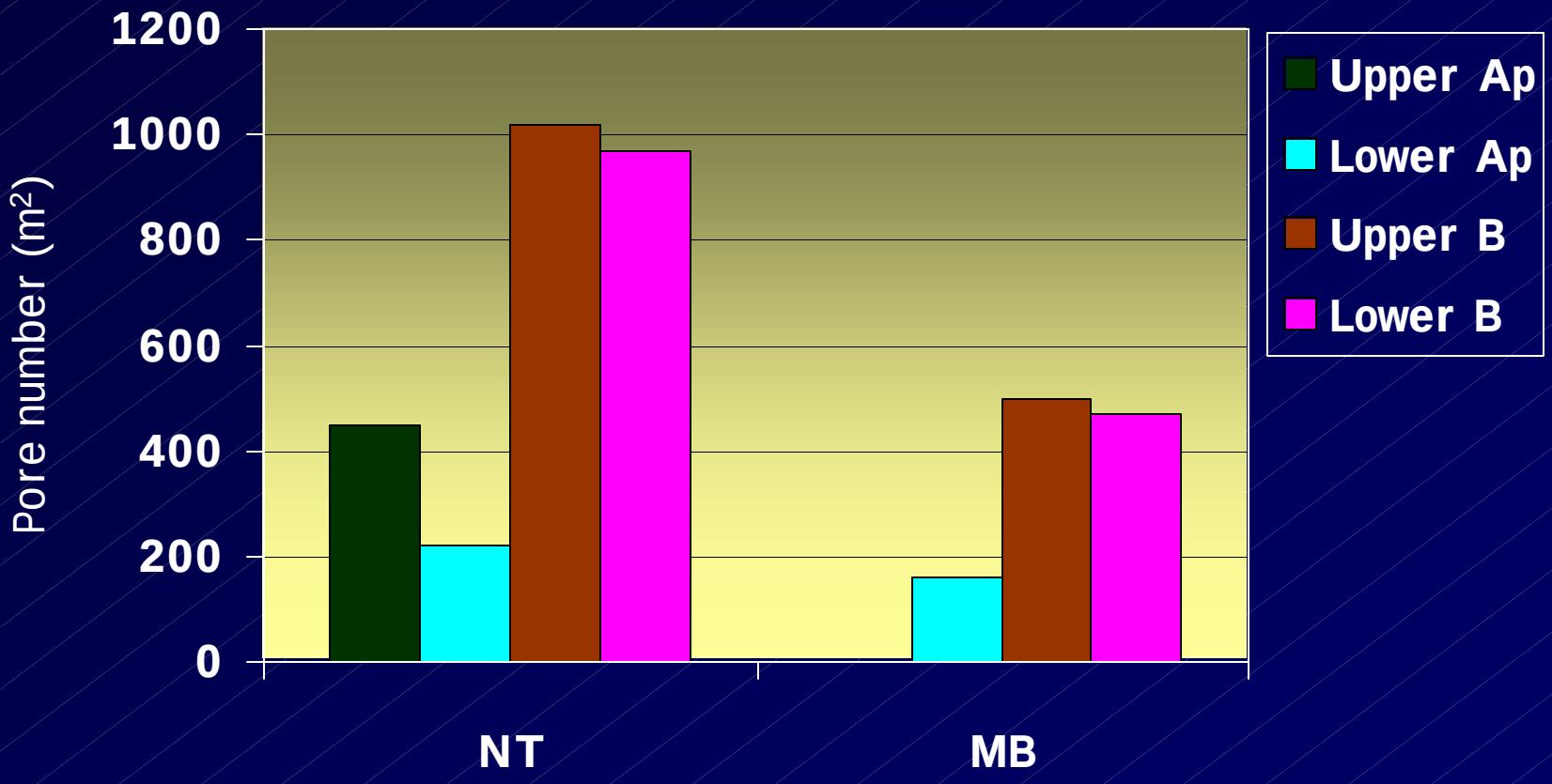


Effects of long-term tillage on the plow layer pore size distribution



Hill et al., 1985

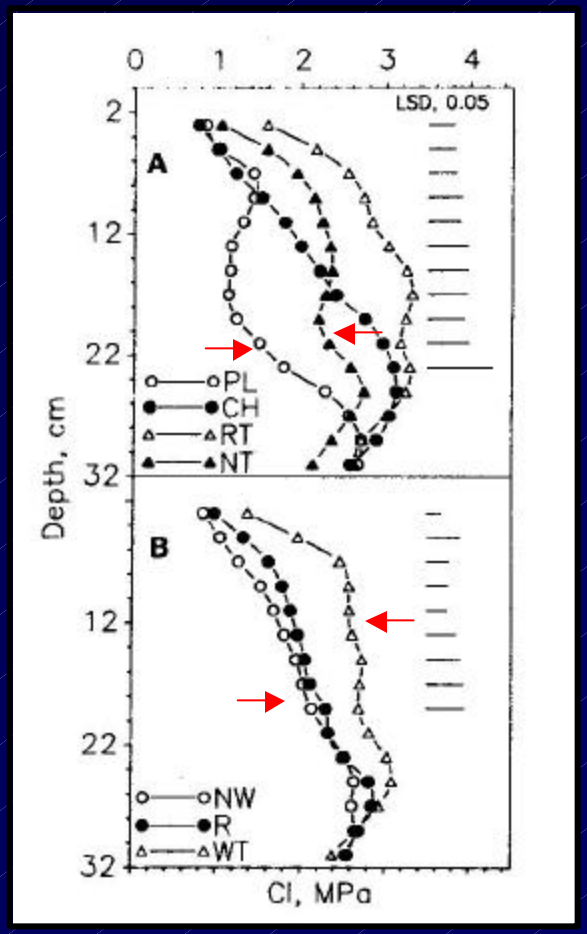
Effects of long-term tillage management on macro-pore (<0.4 mm) continuity



Lancaster, Wis.; continuous corn (Logsdon et al., 1990)

Effects of long-term reduced-tillage

- Lower penetration resistance in NT at depth compared to chisel and no-till
- Greater penetration resistance in wheel track



Larney and Kladivko, 1989

Fertilizer placement affects corn root distribution (0-6 in.)

		Root length (km/m^3)		
Tillage	Fert. placement	Row	Untracked Inter-row	Tracked Inter-row
CH	ROW	17.1	3.0	0.8
CH	INTER-ROW	12.0	4.4	1.4
NT	ROW	19.8	2.5	0.8
NT	INTER-ROW	10.8	6.1	1.5

Kaspar et al., 1991

Controlled traffic is a key to making reduced tillage work

- Controlled traffic research, Australia
- Practiced on 2.5 million acres
- 500 GPS guided tractors
- Research shows 10-15% yield increase from controlled traffic

Tillage effects on N availability

No-till/reduced tillage:

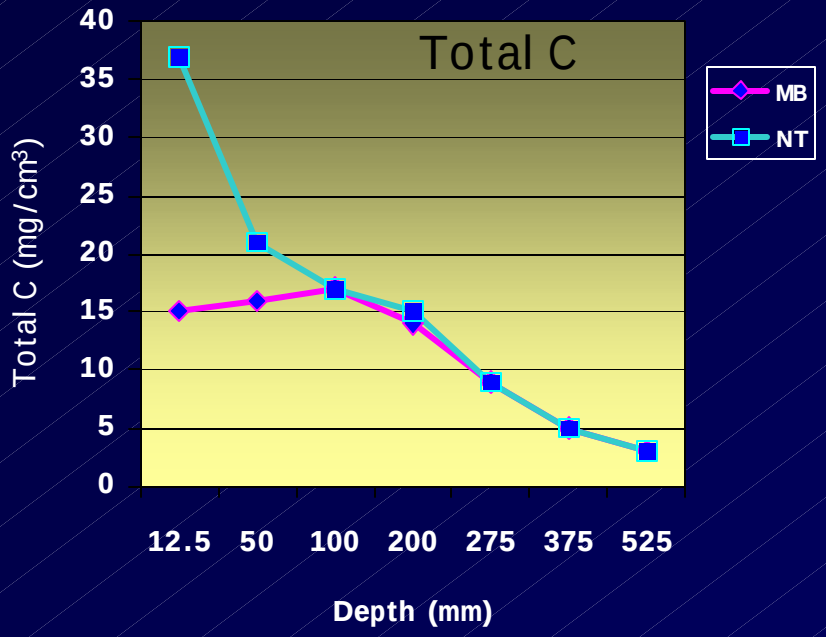
- Lower and slower mineralization
- Greater immobilization
- Volatilization of ammonia from urea and urea-containing materials
- Potential for increased denitrification
- Net result is often reduced availability

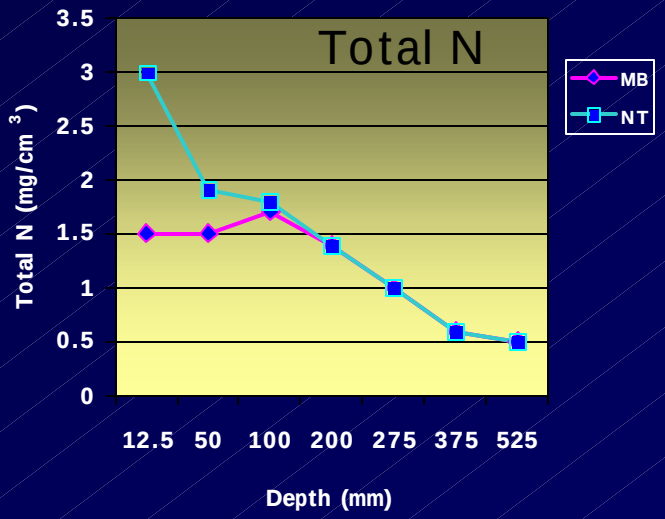
Continuous no-till corn typically has lower N uptake

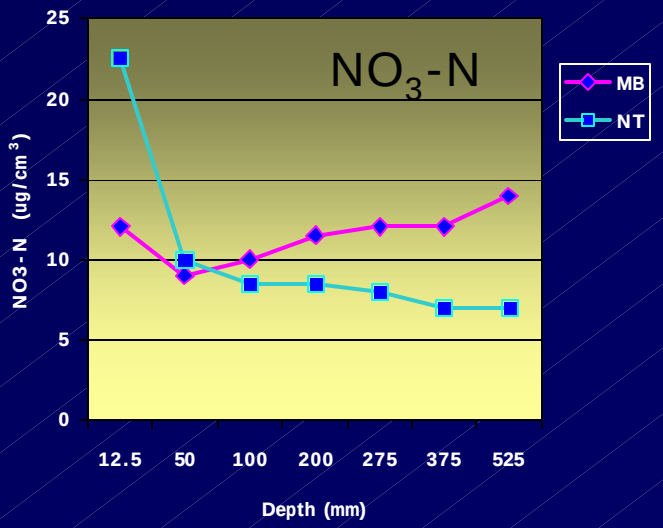
	Oshkosh			Janesville		
Tillage	Earleaf N %	Grain N %	Yield bu/a	Earleaf N %	Grain N %	Yield bu/a
MB	2.92	1.57	159	3.10	1.52	145
CH	2.84	1.55	145	3.05	1.50	137
NT	2.76	1.55	146	2.98	1.47	126

Bundy et al., 1992 (3 yr. avg.)

Soil C and N distribution after 12 years of continuous corn

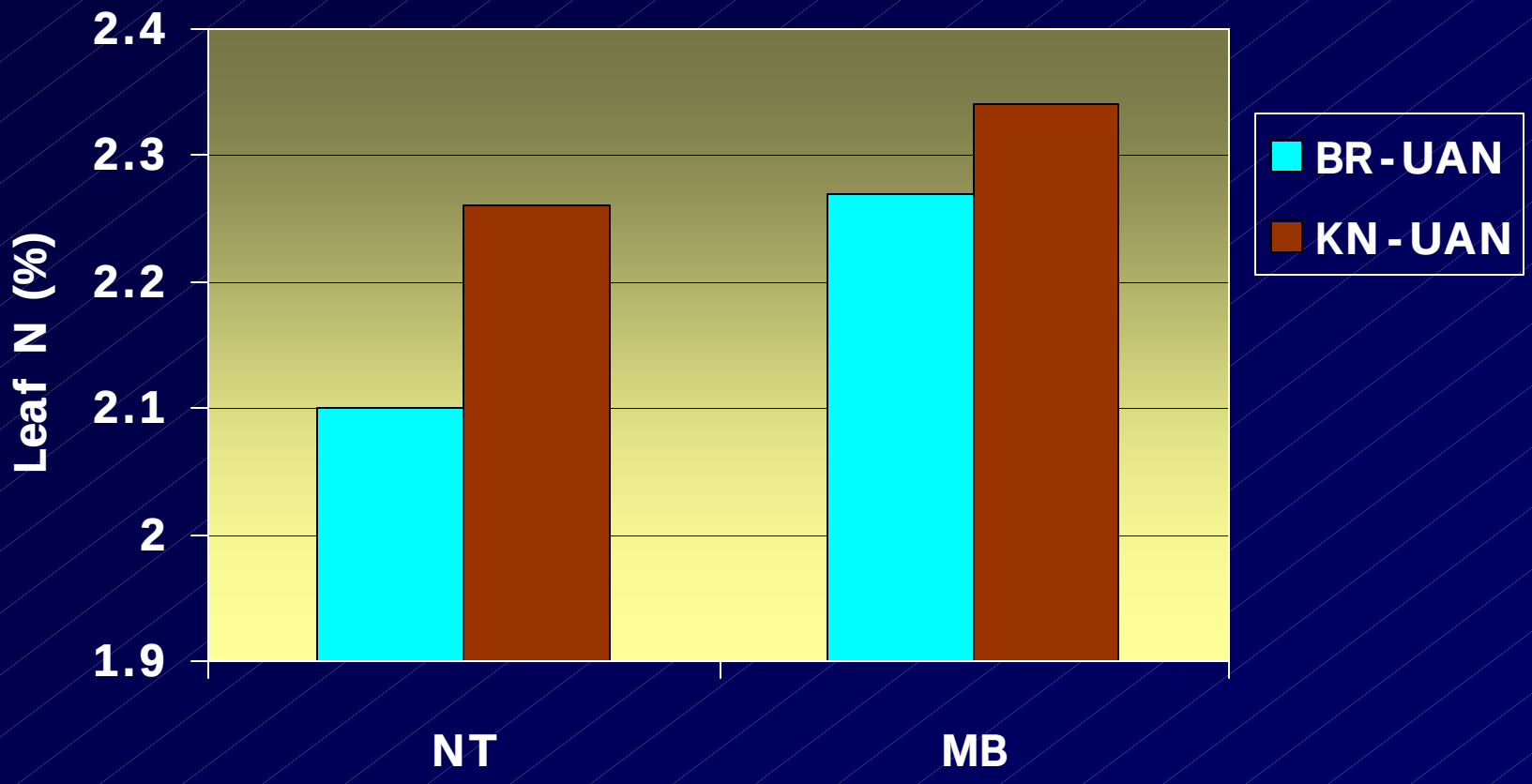






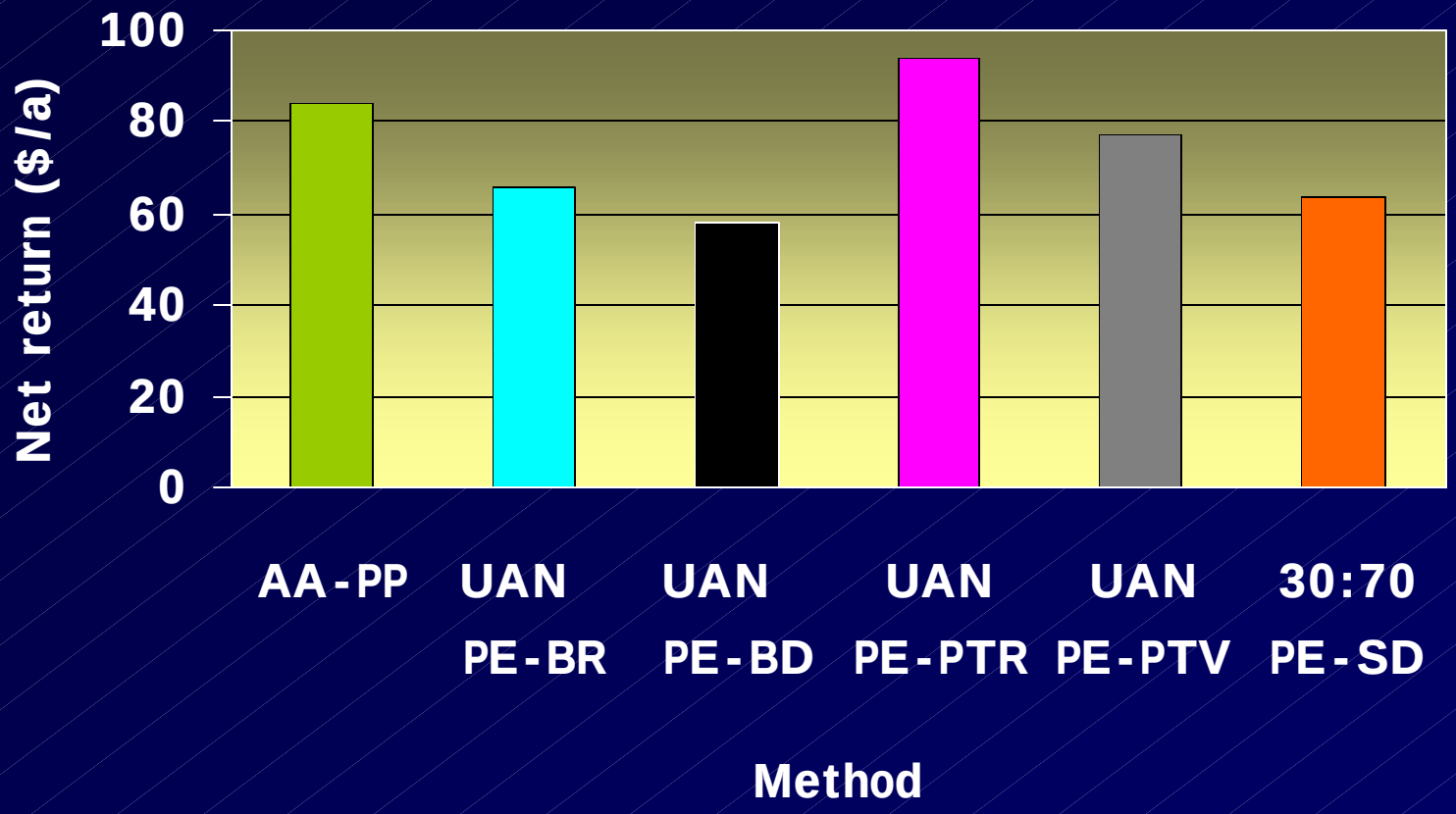
Karlen et al., 1994

Tillage and UAN placement effect on leaf N in grain sorghum



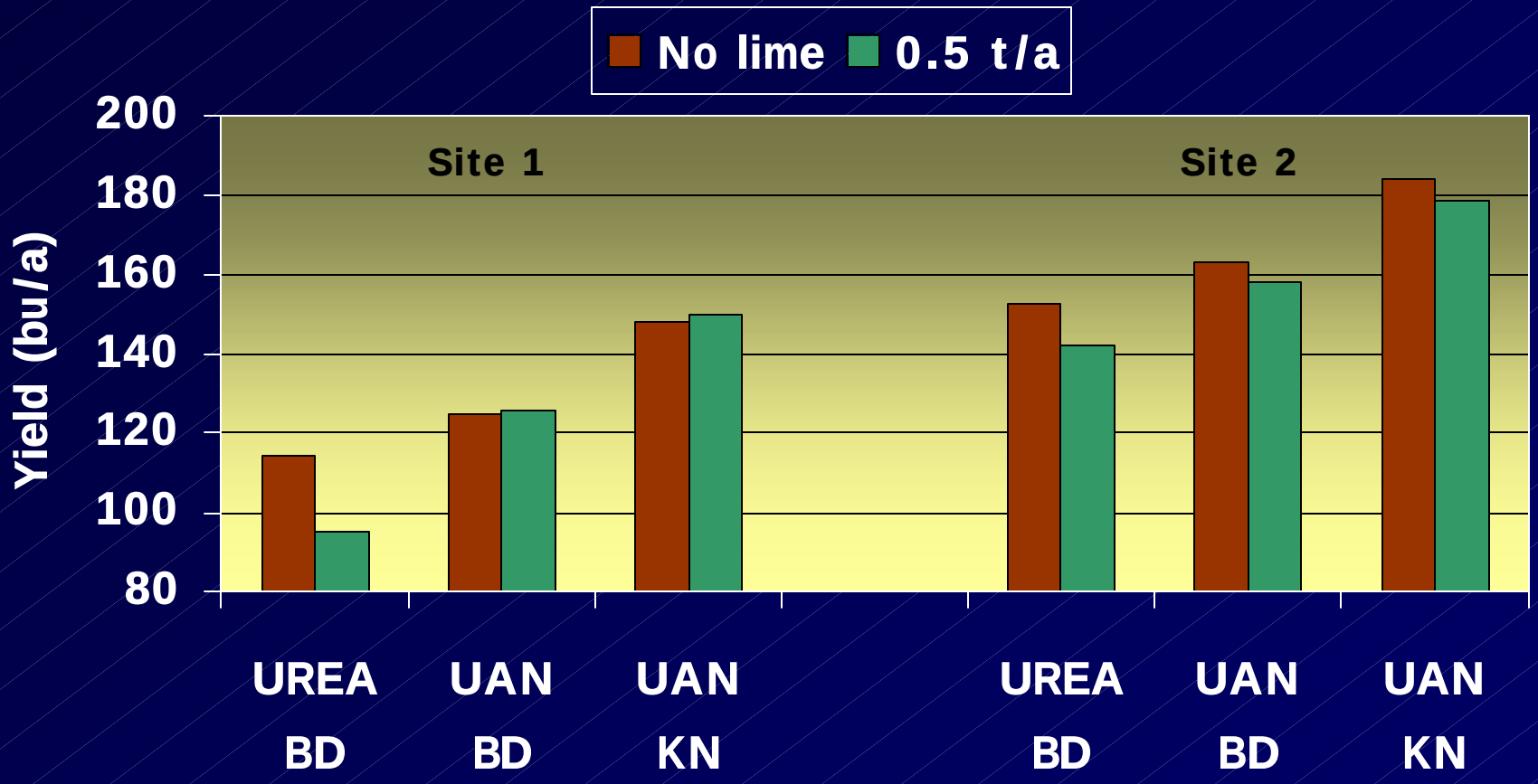
Matowo et al., 1997

Tillage and UAN placement in ridge-till effect on net return to N



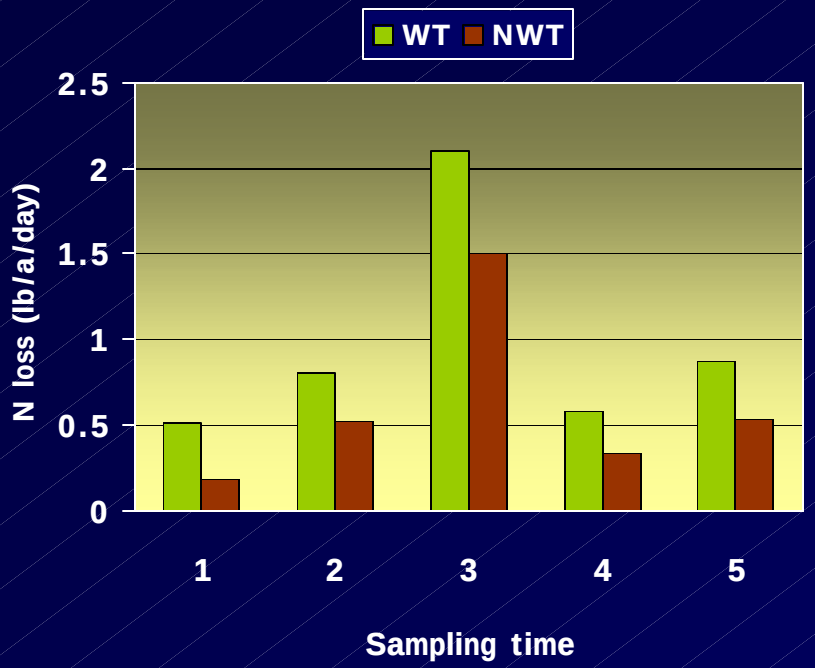
Randall et al., 1997 (all received 100 lb N/a)

Surface urea and liming can be an increase ammonia loss



Howard and Essington, 1998

Tillage and denitrification



- Tillage affected loss:
  - MB = 10 lb/yr
  - CH = 14 lb/yr
  - NT = 22 lb/yr
- No-till
  - Lower air-filled porosity
  - Higher microbial population
  - More surface organic carbon

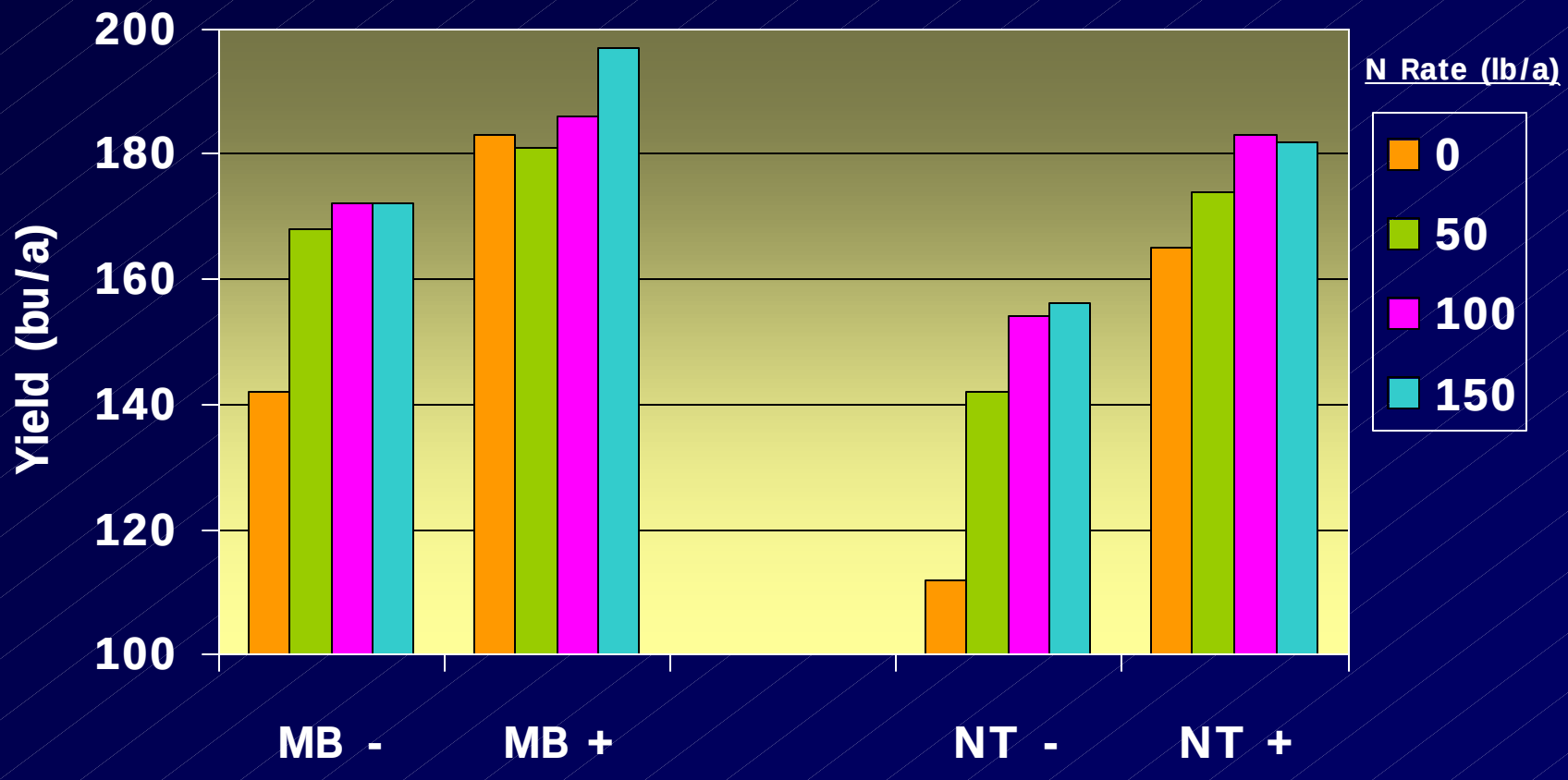
Hilton et al., 1994 (all received 100 lb N/a)

Tillage and nutrient crediting

Possible issues

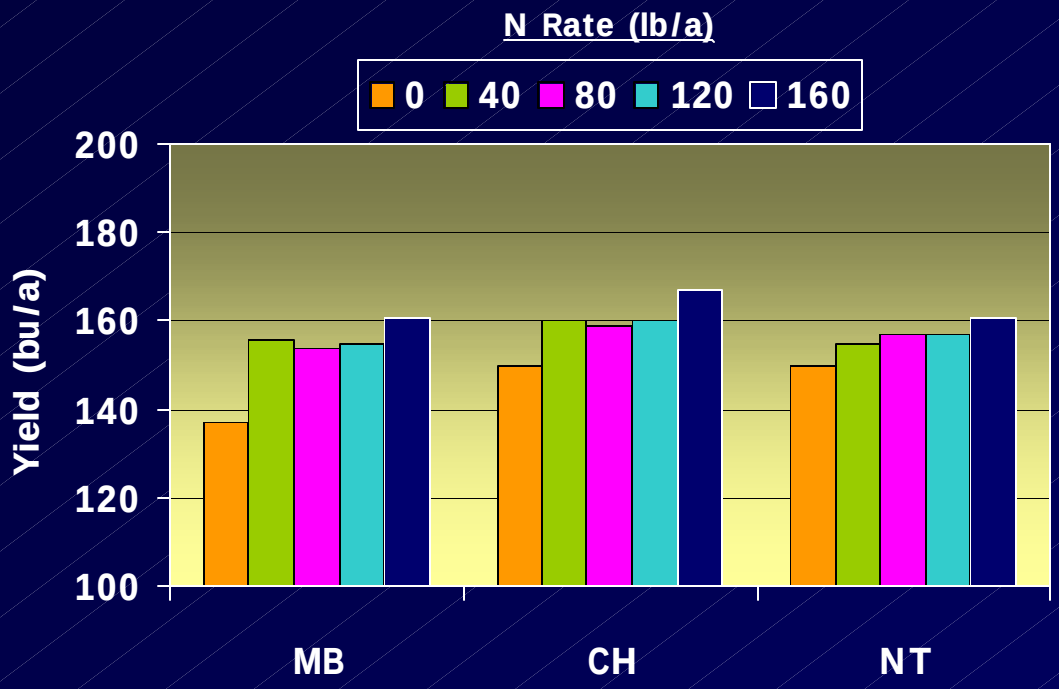
- NH_3 volatilization loss from manure
- Delayed mineralization
- Immobilization in OM
- Synchrony of availability

Tillage and manure effect on corn yield, Arlington, Wis. (2 yr. avg.)



Wolkowski, unpublished data (Manure rate = 30 t/a)

Tillage and legume effect on corn yield, Lancaster, Wis. (2 yr. avg.)



Wolkowski, 1992

Residual nitrate-N following first-year corn after alfalfa, 1990

	Arlington		Lancaster	
Tillage	0 lb N/a	160 lb N/a	0 lb N/a	160 lb N/a
MB	61	212	49	183
CH	57	233	43	118
NT	84	247	49	177

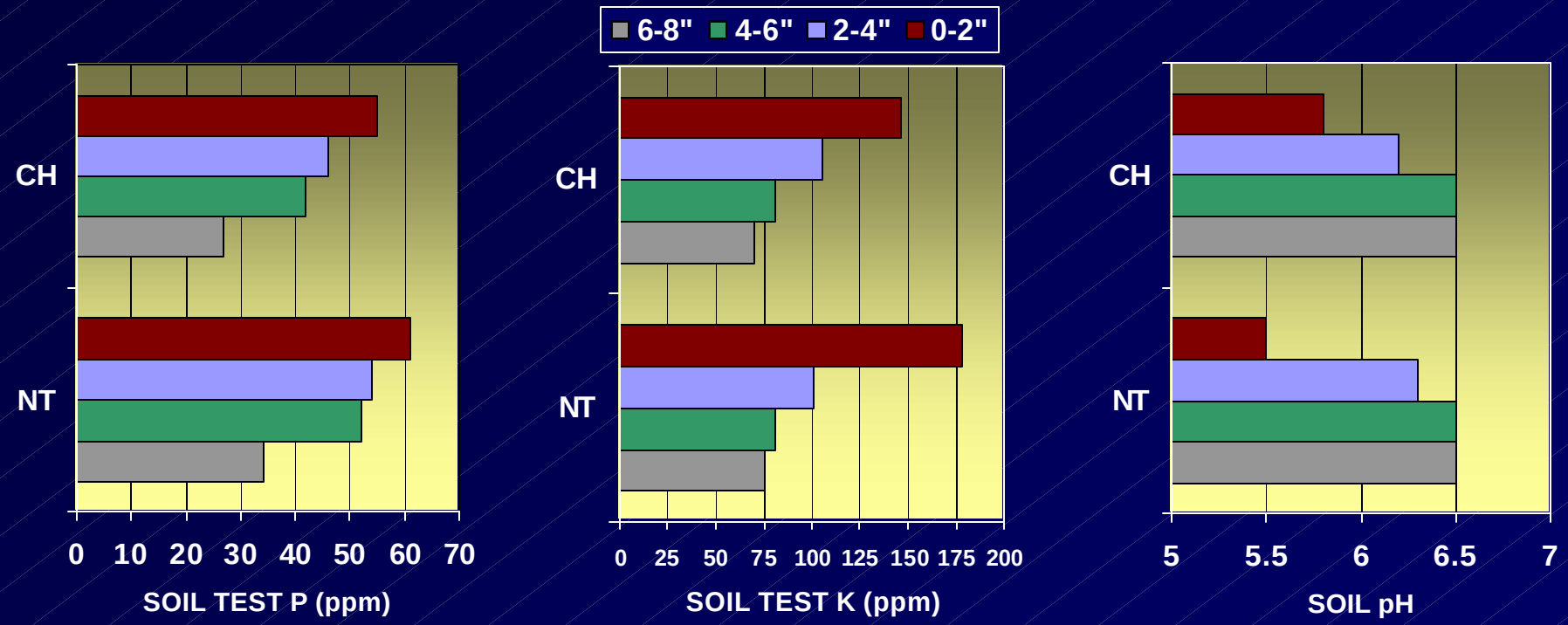
Wolkowski, 1992

Tillage and P and K availability

Possible issues

- Nutrient stratification
  - Surface applied nutrients
  - Crop residues
  - Vertical and horizontal
- How to collect a representative sample
- Fertilizer placement considerations

Soil test stratification following five years of tillage management, Arlington, Wis.



Wolkowski, 2003 (Corn/soybean rotation)

Reduced tillage is more responsive to banding

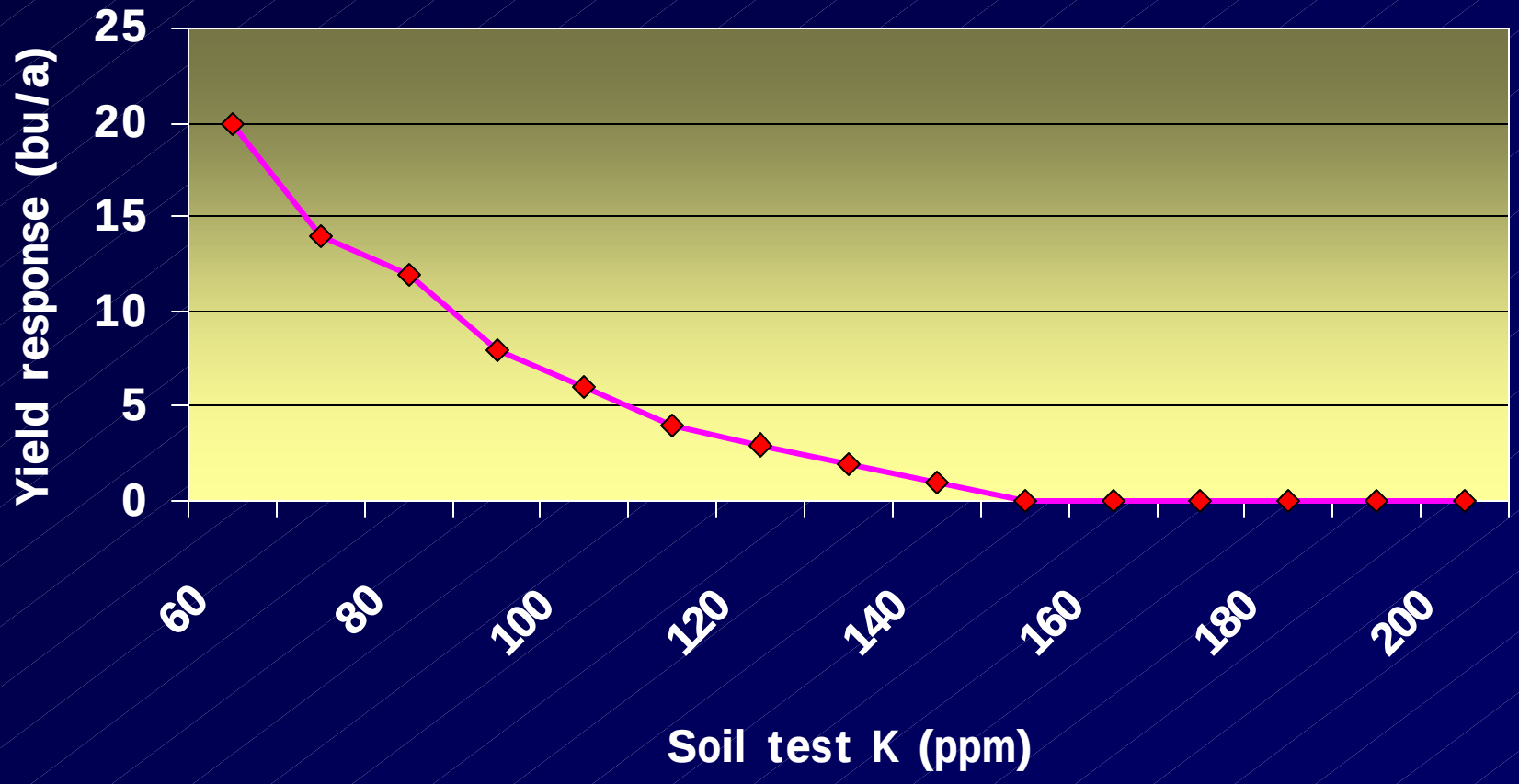
- Positional availability
  - Surface vs. sub-surface
  - Wheel track vs. non-wheel track effects on root distribution
- Reduced P and K fixation by the soil
- Reduced K uptake from zones of poor aeration

EFFECT OF ROTATION, TILLAGE, AND FERTILIZER ON TISSUE K CONCENTRATION 45 DAP, ARLINGTON, WIS., 2001

	CC			SbC		
	CH	ST	NT	CH	ST	NT
	------- % -------			------- % -------		
NONE	2.23	2.37	2.35	1.65	1.34	1.40
BDCT	2.35	2.19	2.51	2.51	2.18	1.40
2 x 2	2.85	3.26	2.31	2.46	2.58	2.16

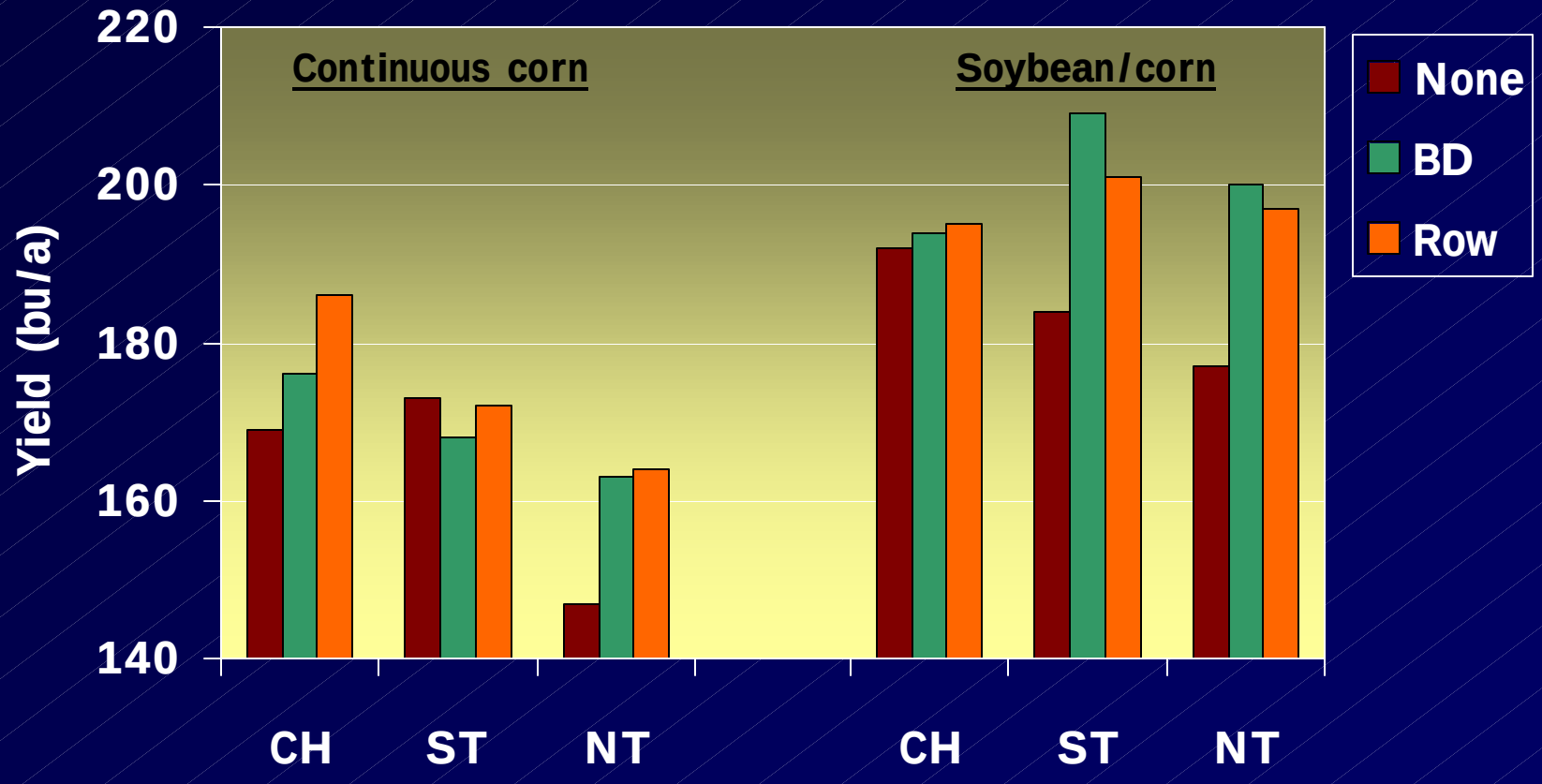
Wolkowski, 2003

Banded K recommended for long-term no-till corn



Adapted fromVyn and Janovicek, 2001

RESPONSE OF CORN TO TILLAGE AND FERTILIZER PLACEMENT, ARLINGTON, WIS. 2001-2003



200 lb 9-23-30/a

Summary

- Tillage has a profound effect on soil properties and affects nutrient availability
- Nitrogen availability tends to be lower in reduced tillage
- N credits for manure and legumes not clearly affected
- pH, P, and K stratify
- No-till corn is more responsive to fertilization
- Band placement often beneficial, however broadcast may be acceptable