TILLAGE EFFECTS ON SOIL PROPERTIES

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WHAT IS TILLAGE

- **THE PHYSICAL MANIPULATION OF THE SOIL FOR THE PURPOSES OF:**
  - **Management of previous crop residues**
  - **Control of competing vegetation**
  - **Incorporation of amendments**
  - **Preparation of a seedbed**

SOIL PROPERTIES AFFECTED BY TILLAGE

- Crop residue cover
- Soil test measurements
- Nutrient availability
- Structure and aggregate stability
- Water relationships
- Temperature
- Strength

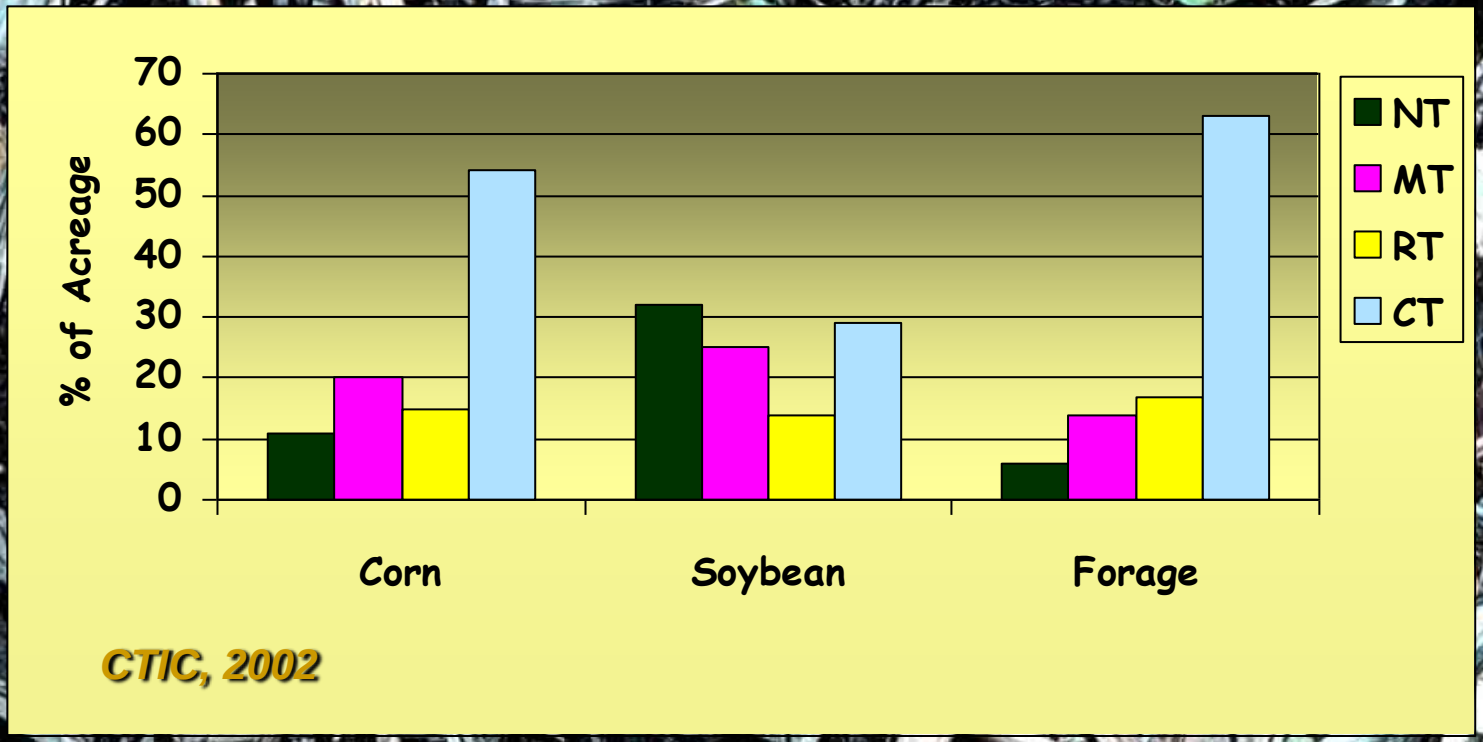
SURFACE CROP RESIDUE INTERACTS WITH OTHER FACTORS

- Impact on erosion
- Cooler soils
- Conserves moisture
- Affects soil physical properties
- Affects carbon and nutrient cycling


TILLAGE EFFECT
EROSION ON CLEAN-TILLED GROUND, DANE CO., WIS.


CROP MANAGEMENT EFFECT
EROSION ON CORN SILAGE
GROUND SHAWANO CO., WIS.

TILLAGE INTENSITY IN WISCONSIN VARIES BY CROP

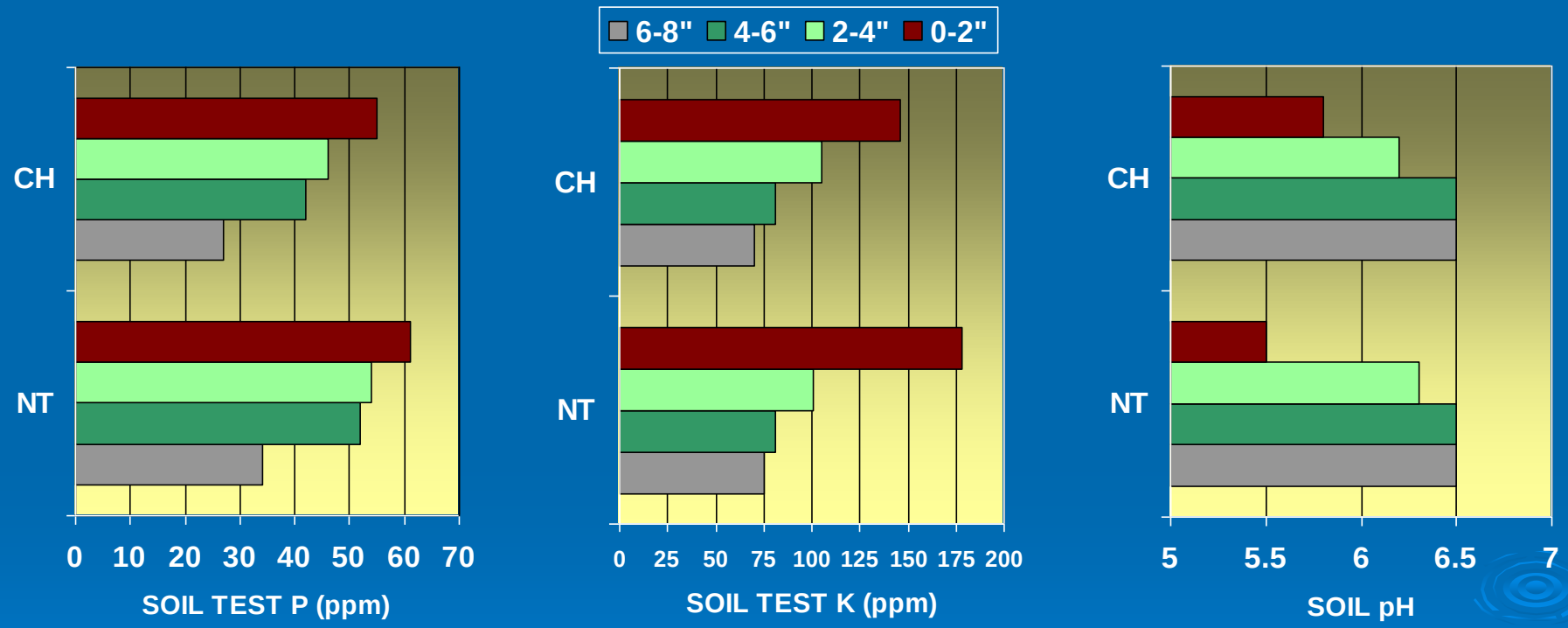


CTIC, 2002

EFFECT ON SOIL TEST

- **Nutrients "stratify" in long-term no-till**
  - **Surface acidification**
  - **Soil sampling concerns**
  - **Benefit to P and K banding**
  - **Banded fertilizer response more likely in no-till**

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**

FERTILIZER PLACEMENT AFFECTS CORN ROOT DISTRIBUTION (0-15 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

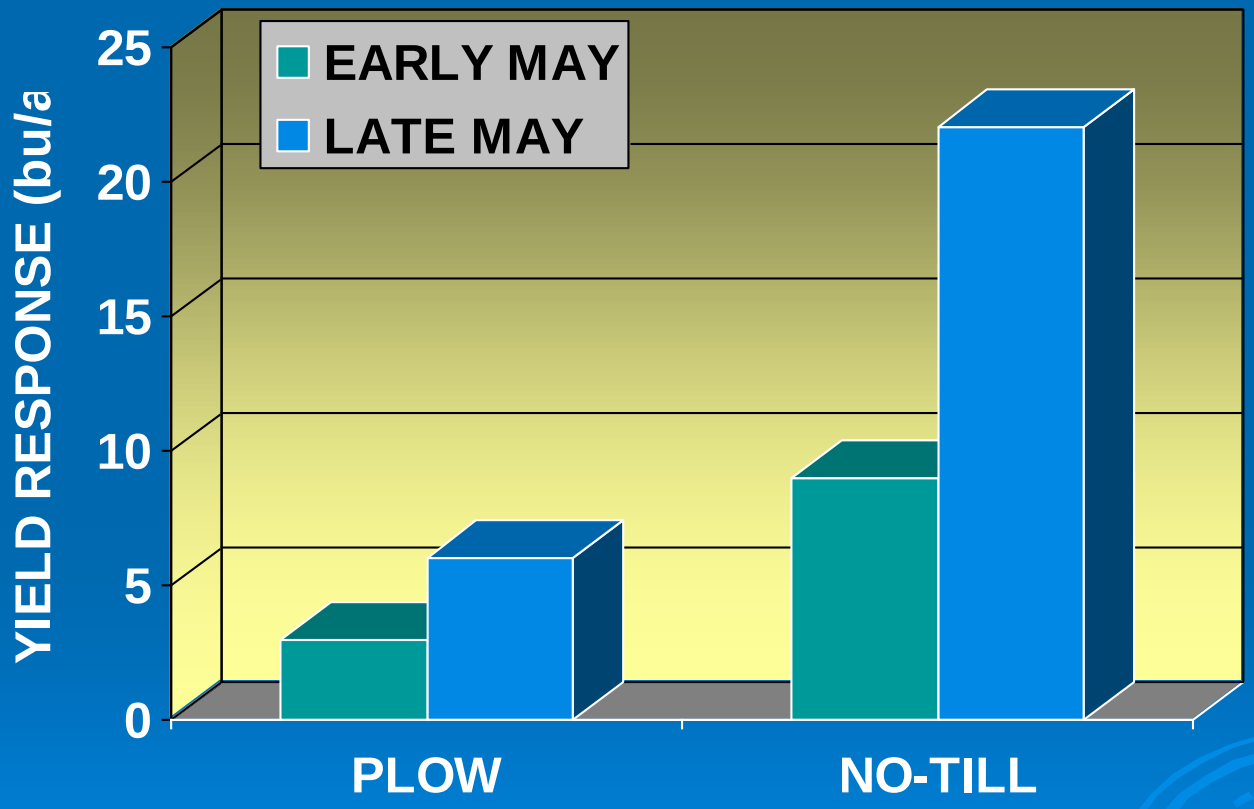
Kaspar et al., 1991

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

	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

CORN RESPONSE TO STARTER: PLANTING DATE AND TILLAGE



BUNDY AND WIDEN, 1991 (3 YR. AVG.)

LOWER N AVAILABILITY IN REDUCED TILLAGE SYSTEMS

No-till/reduced tillage:

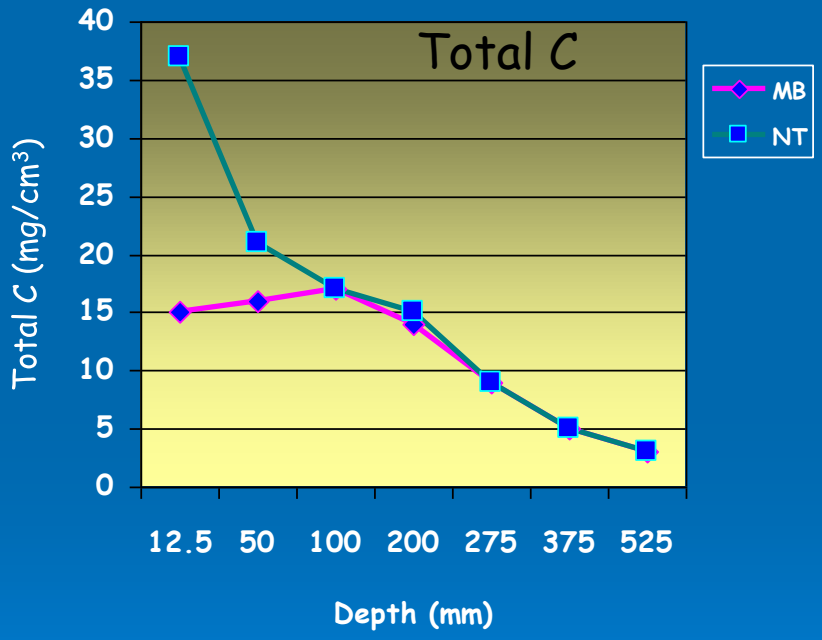
- **Lower and slower mineralization**
- **Greater immobilization**
- **Volatilization of ammonia from surface urea and urea-containing materials**
- **Potential for increased denitrification**
- **Higher supplemental N rate for >50% corn residue recommended (30 lb N/a)**

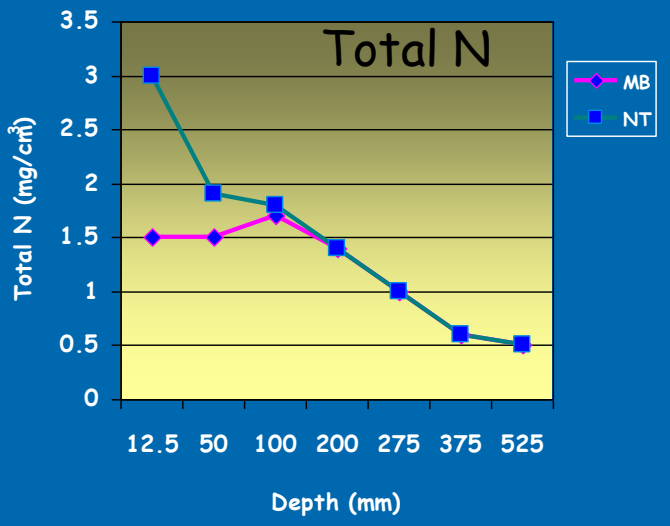
CONTINUOUS NO-TILL CORN TYPICALLY HAS LOWER N UPTAKE

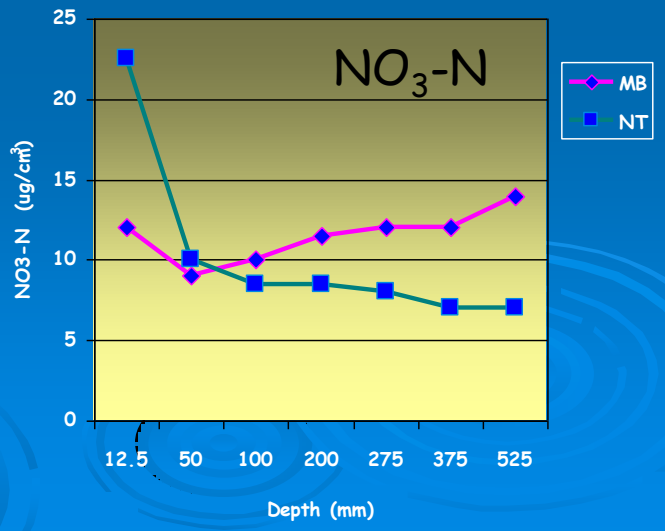
	Oshkosh			Janesville		
Tillage	Earleaf N %	Grain N %	Yield bu/a	Earleaf N %	Grain N %	Yield bu/a
MB	2.92	1.57	159	3.10	1.52	145
CH	2.84	1.55	145	3.05	1.50	137
NT	2.76	1.55	146	2.98	1.47	126

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

SOIL C AND N DISTRIBUTION AFTER 12 YEARS OF CONTINUOUS CORN

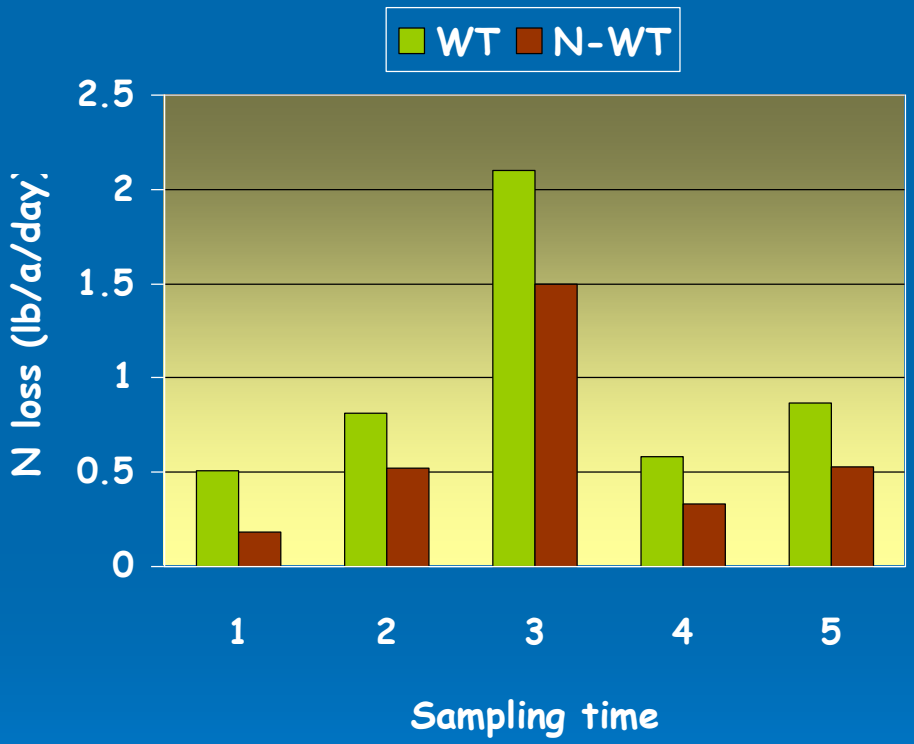






Karlen et al., 1994

TILLAGE AND DENITRIFICATION



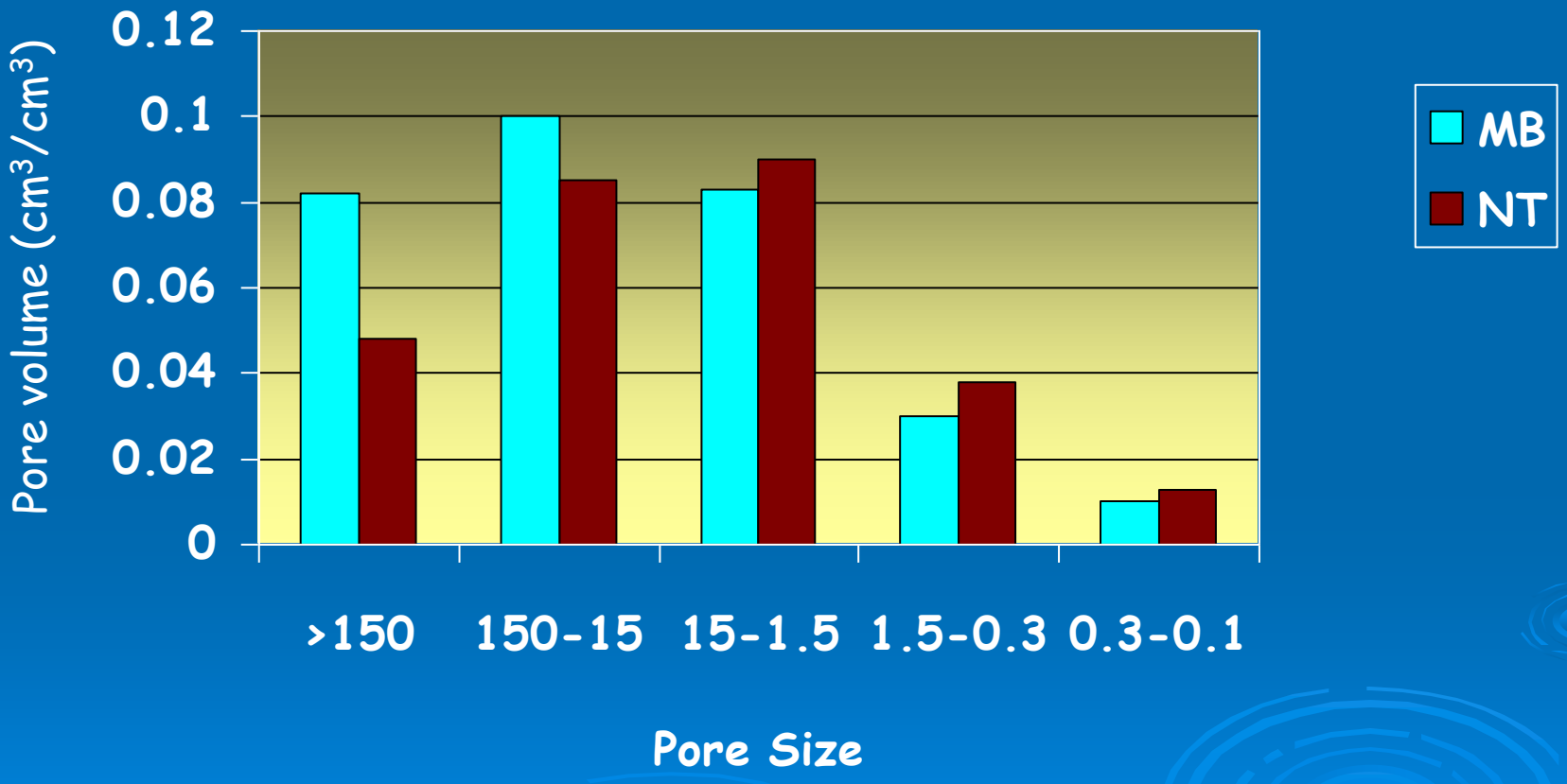
- Tillage affected loss:
  - MB = 10 lb/yr
  - CH = 14 lb/yr
  - NT = 22 lb/yr
- No-till
  - Lower air-filled porosity
  - Higher microbial denitrifier population
  - More surface organic carbon

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

TILLAGE HAS A PROFOUND EFFECT ON THE SOIL PHYSICAL CONDITION

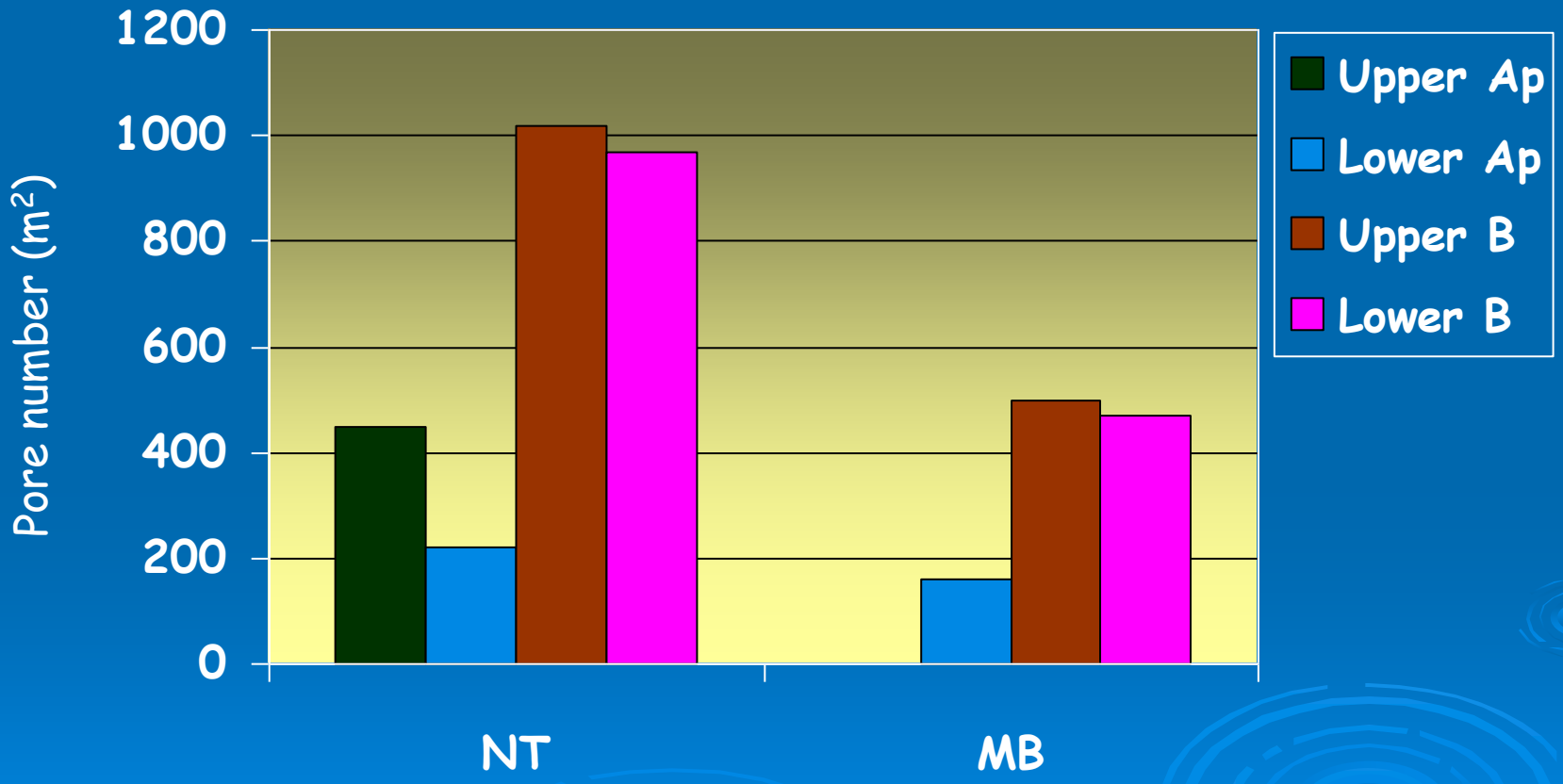
TEN BOTTOM MOLDBOARD PLOW SET AT 11", WOOD CO., WIS.

EFFECTS OF LONG-TERM TILLAGE ON THE PLOW LAYER PORE SIZE DISTRIBUTION



Hill et al., 1985

EFFECTS OF TILLAGE MANAGEMENT ON MACRO-PORE (>0.4 mm) CONTINUITY



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

AGGREGATE STABILITY

- **INFLUENCED BY**
  - **Organic matter and organisms**
  - **Texture**
  - **Rotation**
  - **Tillage**
- **IMPORTANT FOR:**
  - **Aeration**
  - **Water relations**
  - **Productivity**

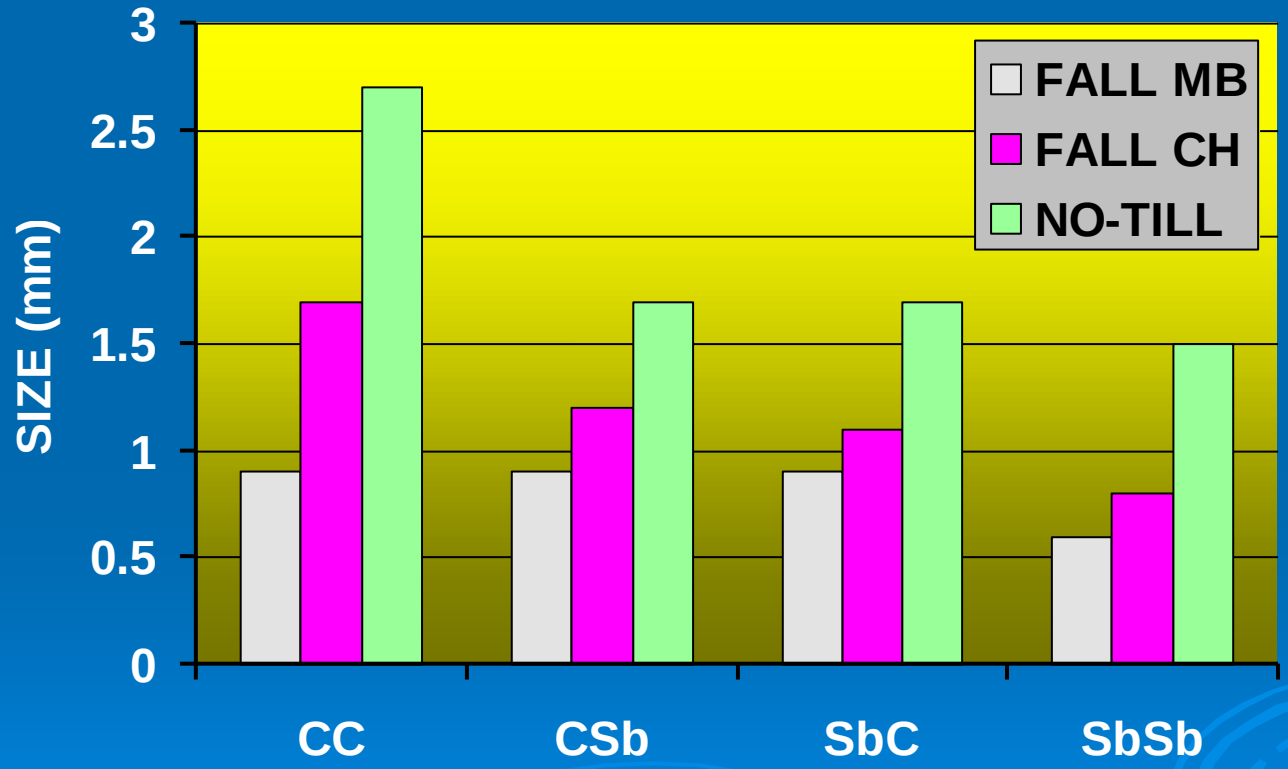

“HEALTHY” CORN ROOT MASS

TILLAGE EFFECTS ON SOIL (0-2 IN.) PROPERTIES AT LANCASTER, WIS.

TILLAGE	STAB. AGGR.	TOTAL C	EARTH WORMS	RUNOFF
	%	g/kg	No./m^2	Mg/ha
No-till	46	24	78	2.1
Chisel	34	16	52	--
Plow	36	11	53	0.5

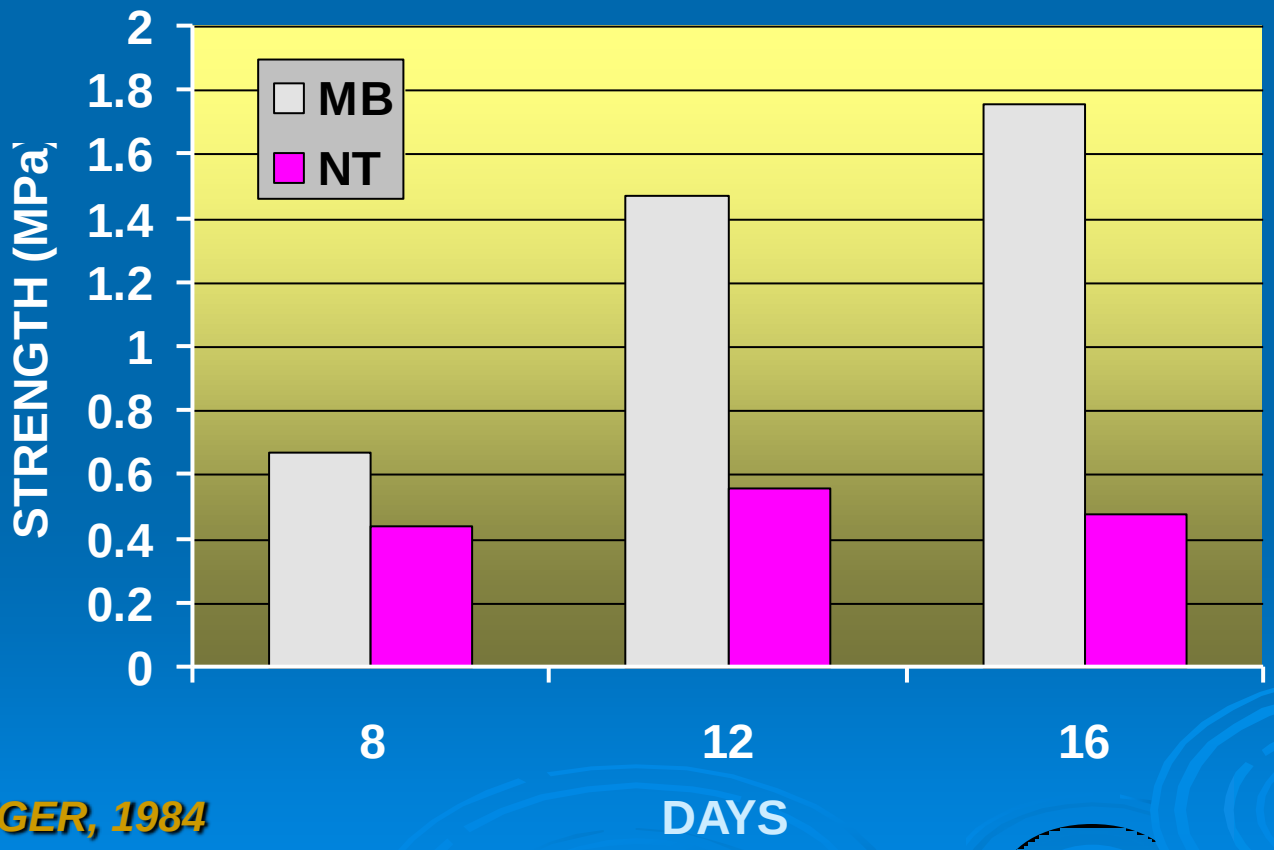
Karlen et al., 1994

WATER-STABLE AGGREGATE SIZE IN THE 0-3 IN. DEPTH AS AFFECTED BY ROTATION AND TILLAGE



Kladivko et al, 1986

EFFECT OF TILLAGE ON CRUST STRENGTH AFTER A HEAVY RAINFALL



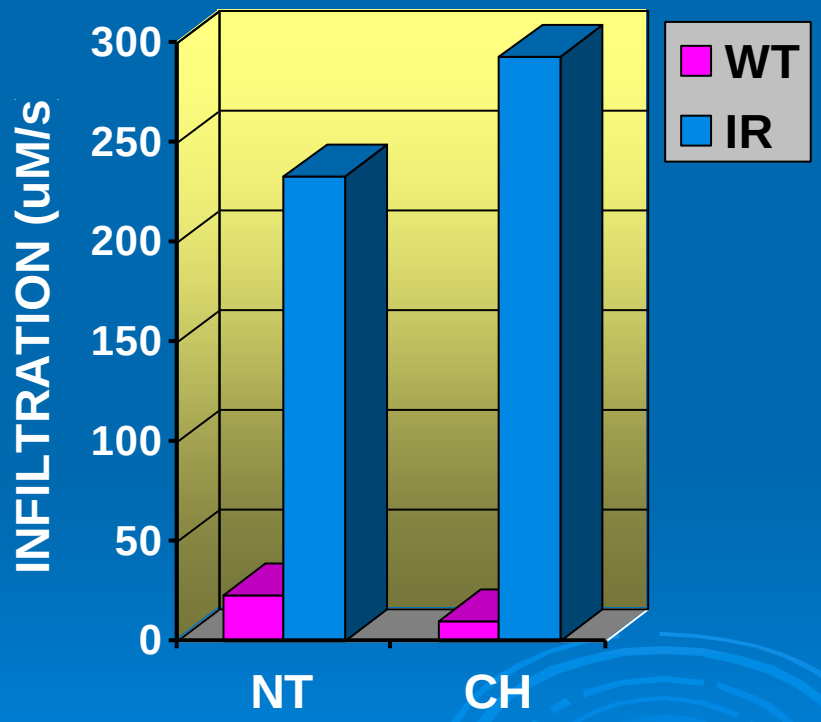
UNGER, 1984

TILLAGE EFFECTS ON SOIL WATER RELATIONSHIPS

- **No-till soils tend to have lower porosity and higher water content**
- **Considerable variability by soil type**
- **Continuous channels in no-till can increase infiltration rate**

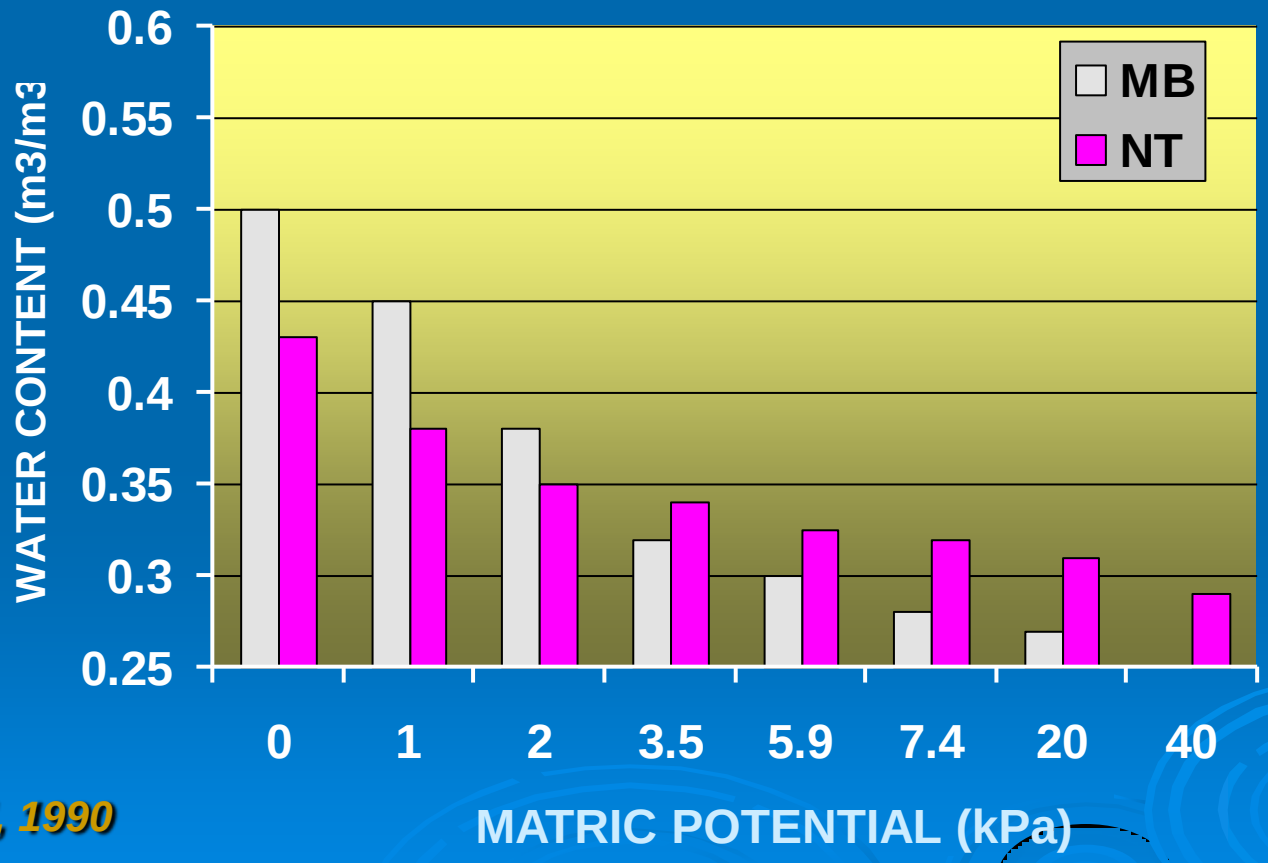
TILLAGE EFFECT ON INFILTRATION

- No-till maintains large pores
- Bare soil crusts
- Infiltration varies during season
- Wheel traffic influences infiltration



Ankeny et al., 1990

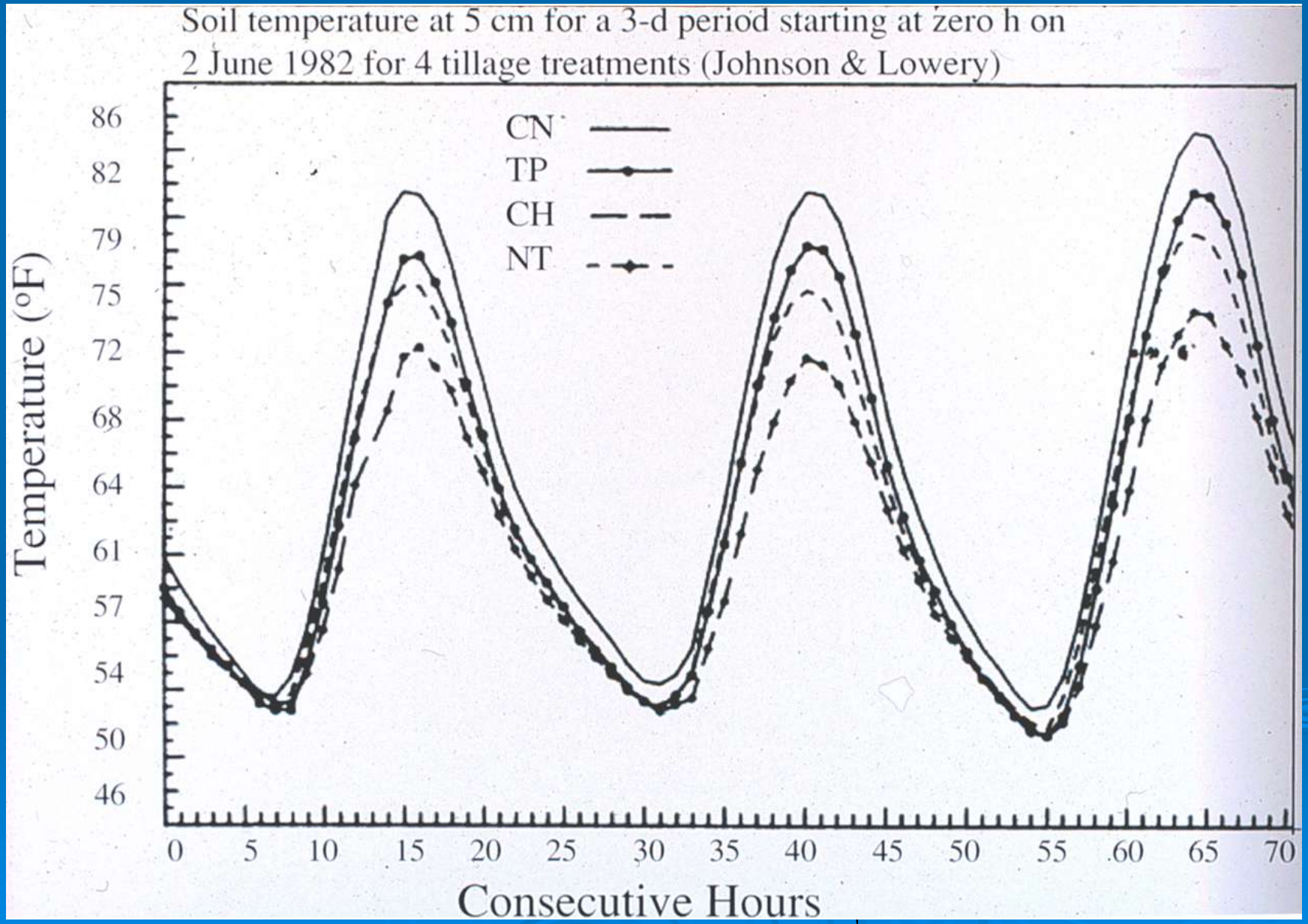
RELATIONSHIP BETWEEN SOIL MATRIC POTENTIAL AND VOLUMETRIC WATER CONTENT



Hill, 1990

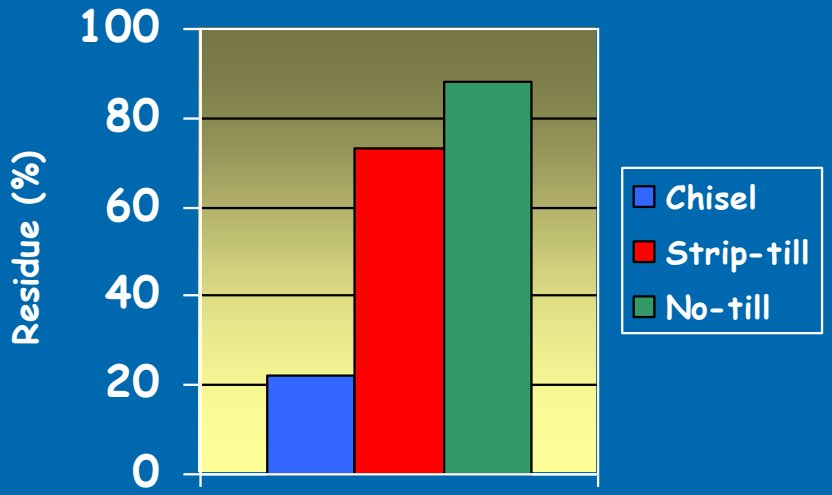
TILLAGE EFFECTS ON SOIL TEMPERATURE

- **Cooler temperatures associated with high residue**
- **Residue buffers temperature change**
- **Emergence and early growth affected**
- **No-till systems have been shown to be 5-10% less productive in Wisconsin**

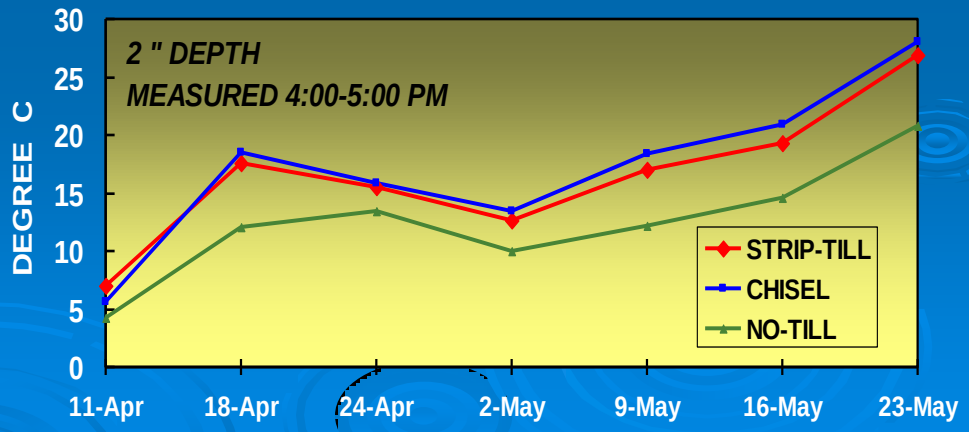

Soil temperature at 5 cm for a 3-d period starting at zero h on
2 June 1982 for 4 tillage treatments (Johnson & Lowery)
CN
TP
CH
NT
Temperature (°F)
86
82
79
75
72
68
64
61
57
54
50
46
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Consecutive Hours

SOIL TEMPERATURE AFFECTED BY TILLAGE AND CROP RESIDUE

Effect on crop residue, Arlington, 1994



Effect on in-row soil temperature, Arlington, 1994



Wolkowski, 2000

EFFECT OF TILLAGE ON THE EARLY GROWTH OF CORN, ARLINGTON, WIS.

TILLAGE	EMERGENCE	V6	V12	SILKING
	plt/ft	-------- g/plt --------		%
Strip-till	1.6	1.1	28	62
Chisel	1.8	1.1	29	80
No-till	0.7	0.7	18	36

Wolkowski, 2000


STRIP TILLAGE OFFERS
AN ALTERNATIVE TO
FULL-WIDTH TILLAGE

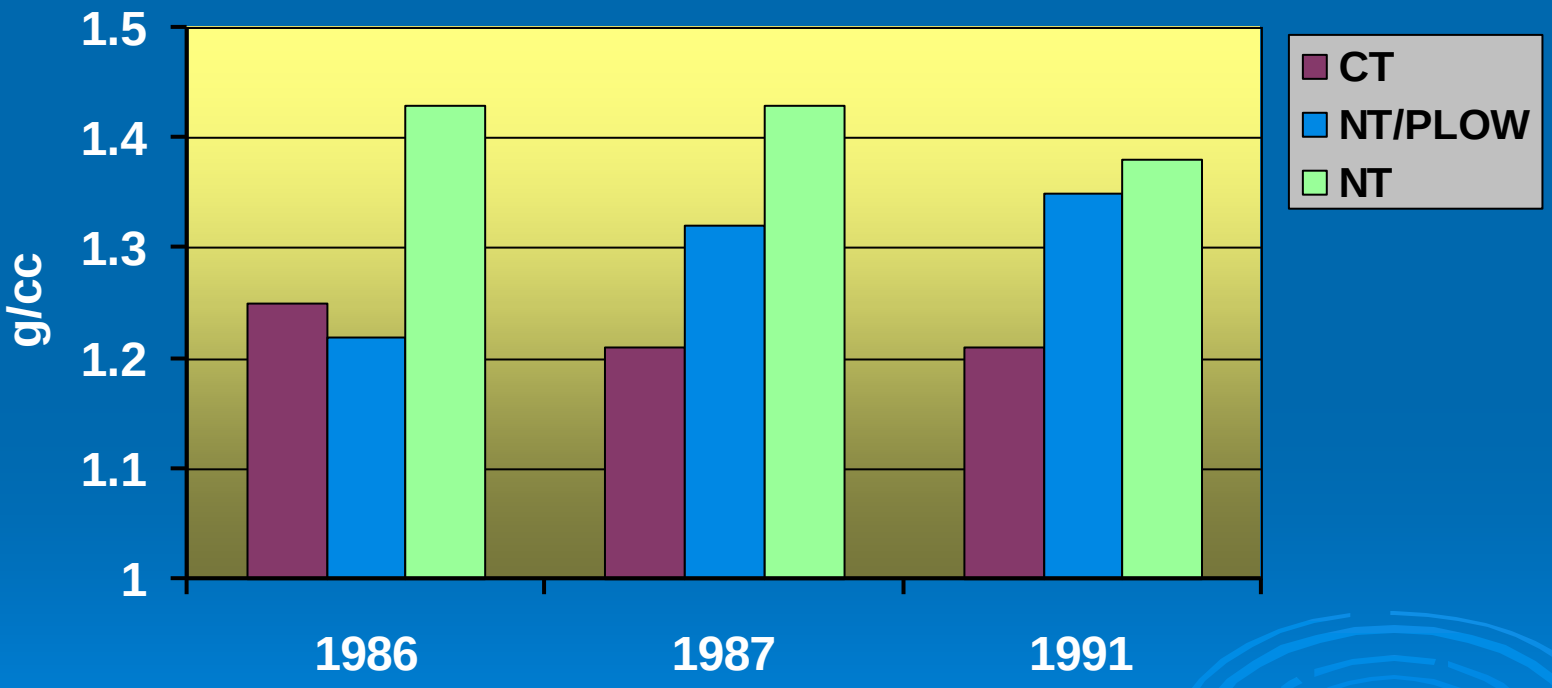
IN-ROW RESIDUE MGT.
ZONE-TILL PLANTER


STRIP TILLAGE OFFERS AN ALTERNATIVE TO FULL-WIDTH TILLAGE WITH CONSERVATION AND AGRONOMIC BENEFITS

TILLAGE EFFECTS ON SOIL STRENGTH

- **Reduced tillage soils have higher surface bulk density**
- **Short-term response to occasional tillage**
- **Traffic management critical**
- **Subsoiling response is likely site dependent**

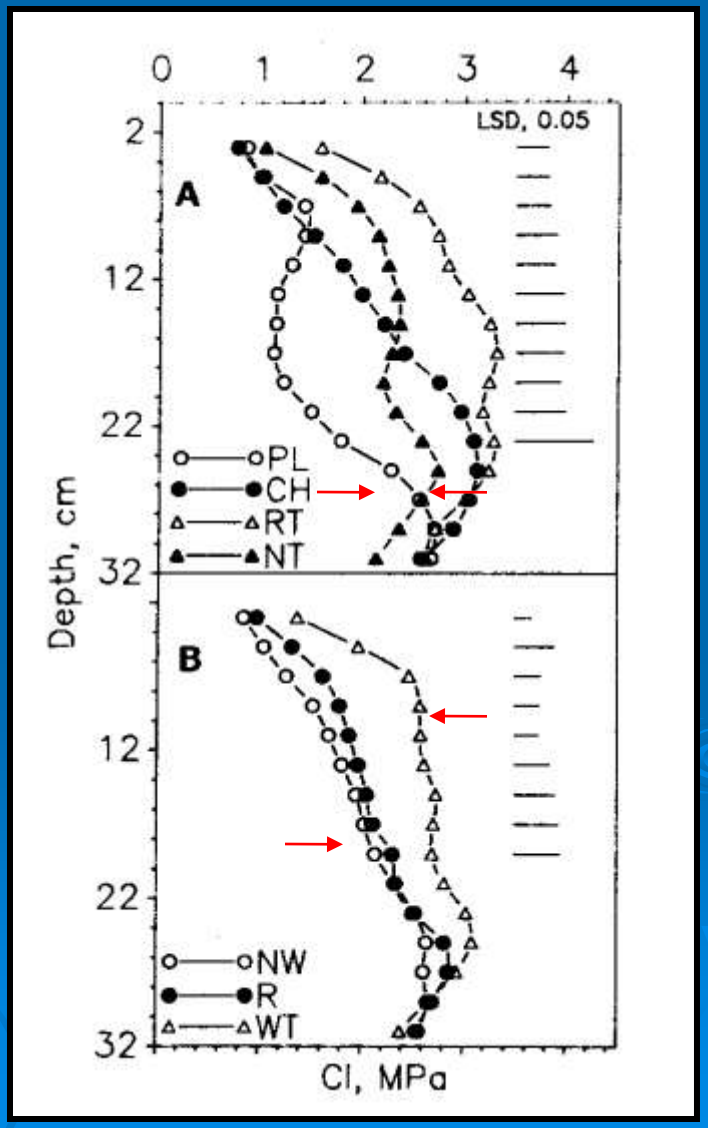
EFFECT OF PERIODIC PLOWING ON SOIL BULK DENSITY (0-3 in.)



Pierce et al., 1994

TILLAGE INFLUENCES RESISTANCE TO PENETRATION

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



Larney and Kladivko, 1989

SOIL PHYSICAL PROPERTIES AND CORN YIELD AS AFFECTED BY TRACKED AND WHEELED VEHICLES

TYPE	BULK DENSITY	HYDR. COND.	AIR-FILLED PORE SPACE	YIELD
	g/cc	uM/sec	%	Bu/a
Un-tracked	1.28	26.0	17.8	166
Steel-tracked	1.38	13.0	9.7	148
Rubber-tracked	1.46	7.8	7.7	--
Wheel-tracked	1.50	2.7	4.7	139

Brown et al., 1992


Given enough horsepower man can do some really dumb things

Compaction affects the soil
- **structure**
- **porosity**
- **aeration**
- **strength**

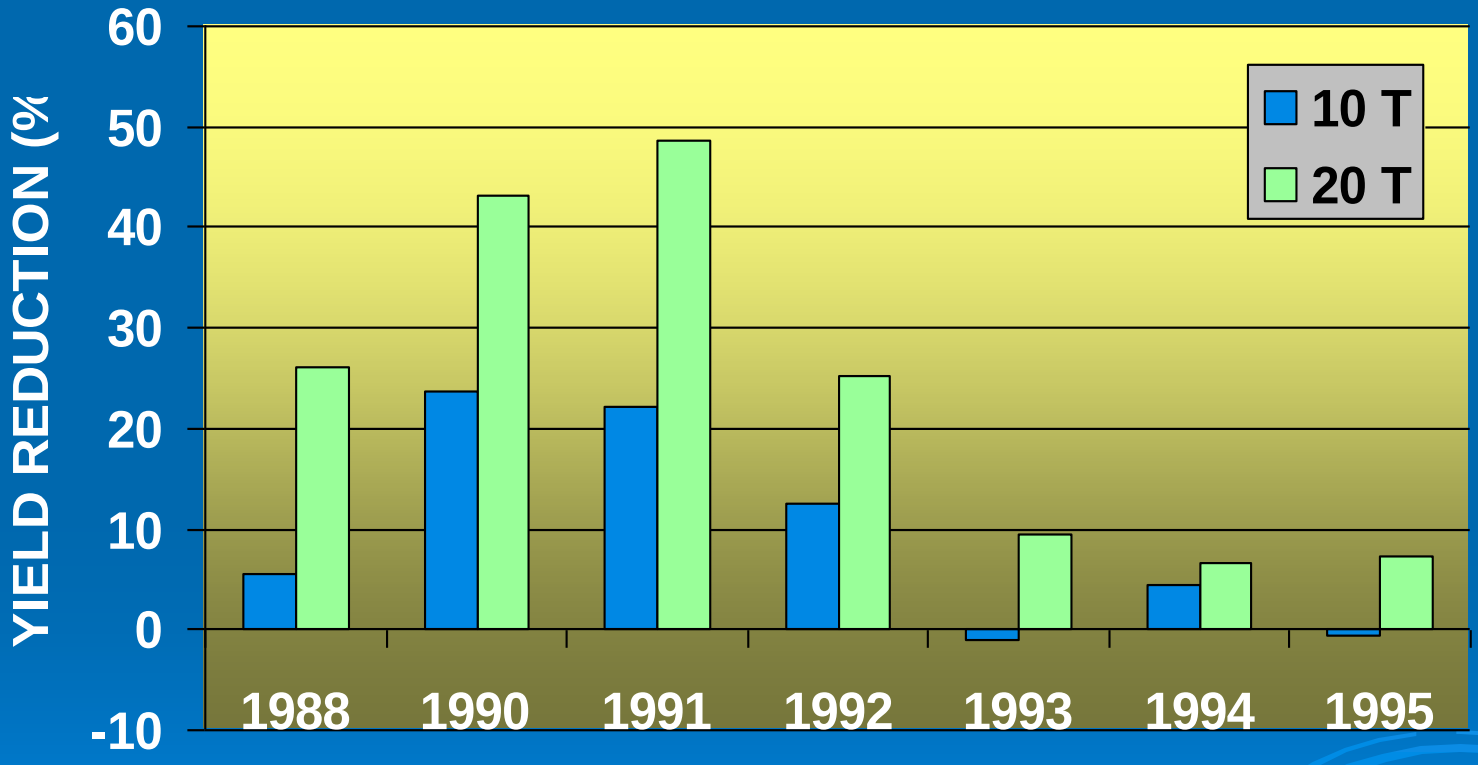
Plant growth affected
- **root growth**
- **nutrient uptake**
- **water utilization**

CORN AND SOYBEAN YIELD AS AFFECTED BY DEEP TILLAGE, MANITOWOC, WIS.

TILLAGE	SOYBEAN 1997	CORN 1998	SOYBEAN 1999	CORN 2000
	---------- bu/a ----------			
NT	30	213	57	176
VR	40	188	58	172
ZB	51*	226*	59	192*

Wolkowski (unpublished)

NATURAL ALLEVIATION OF COMPACTION ON A SILTY CLAY LOAM SOIL



Al-Adawi and Reeder, 1996

SUMMARY

- Tillage management can greatly modify soil properties related to soil quality and crop growth
- Tillage intensity will impact residue management and soil consolidation
- Many physical and chemical properties are affected
- High residue systems need “tweaking” in Wisconsin
- Better traffic and tillage management will enhance soil quality