UNIVERSITY OF MINNESOTA EXTENSION

Economics of Soil Health

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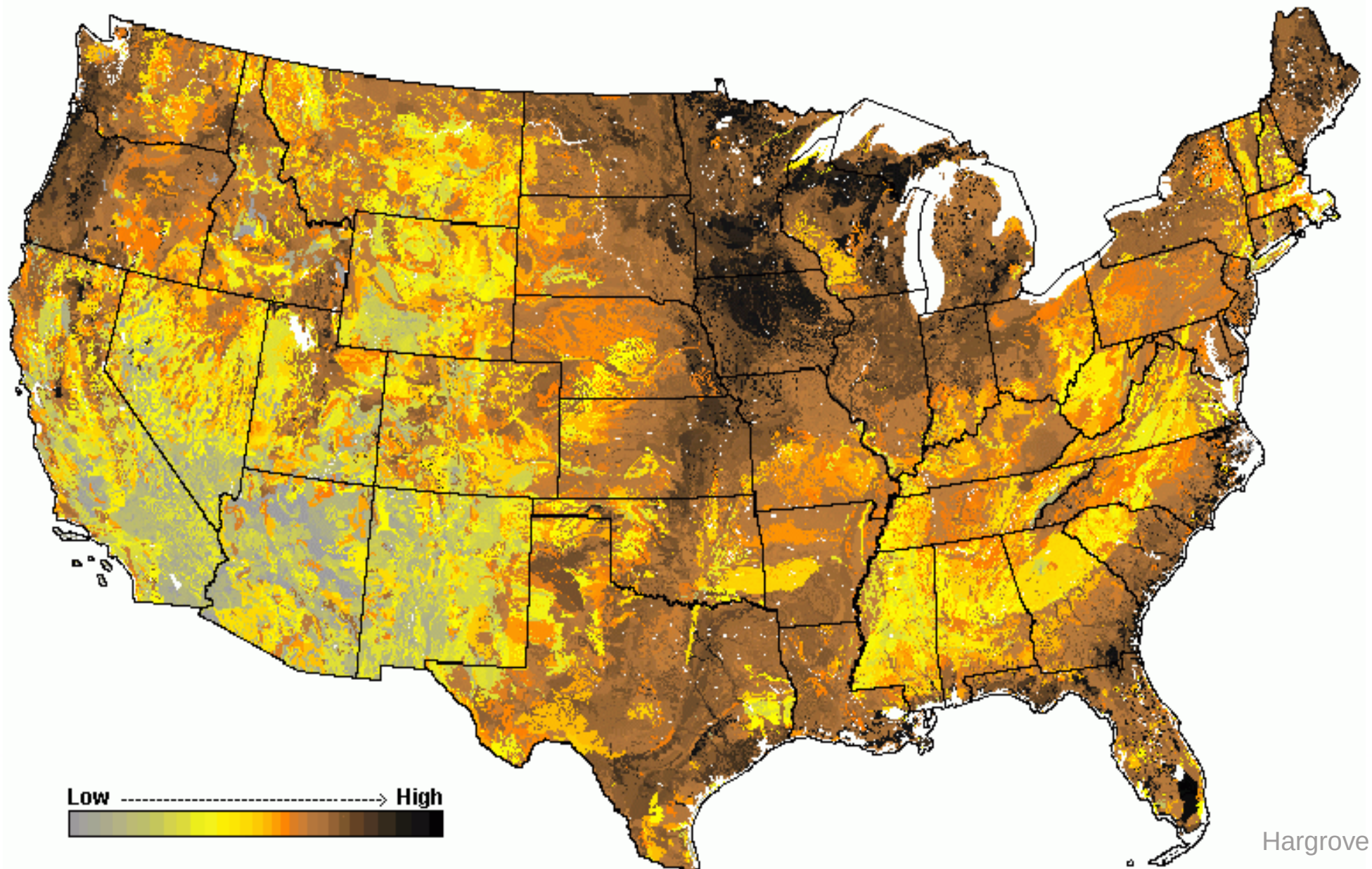
How much farmable land does the earth hold?

www.youtube.com/watch?v=ESbGbfyqK4w

Soil Organic Matter in the US

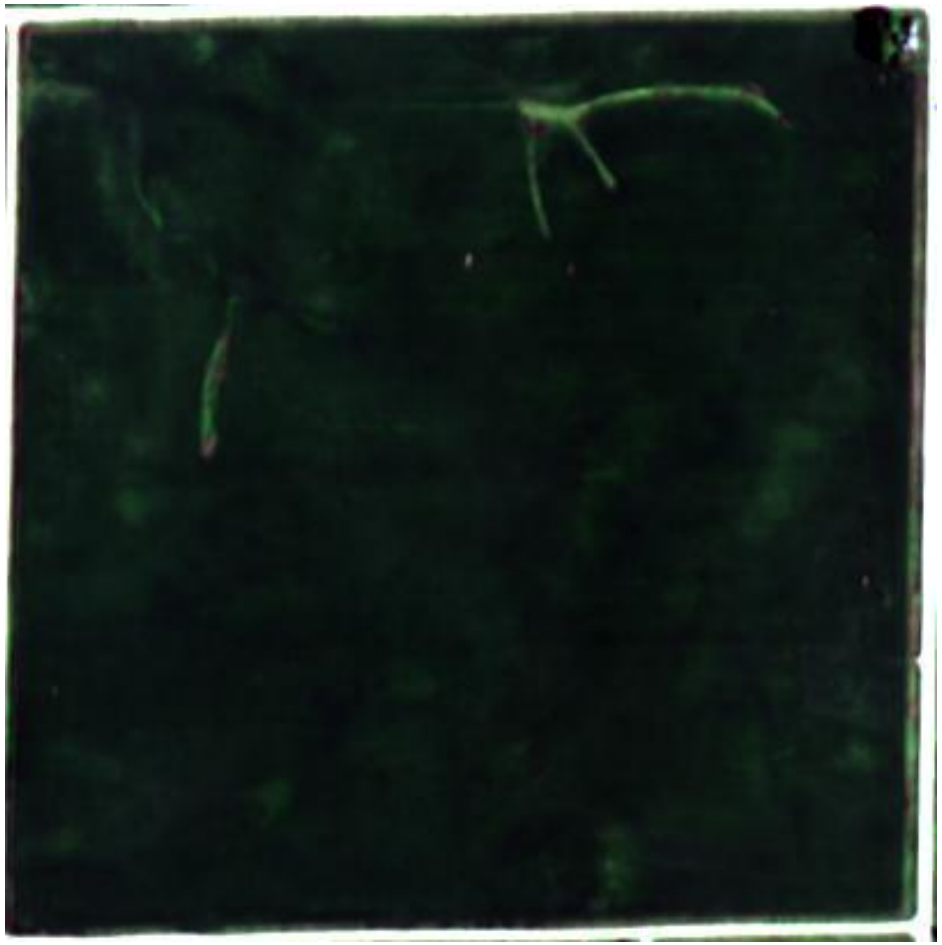


Hargrove and Luxmoore

The Value of Soil Organic Matter

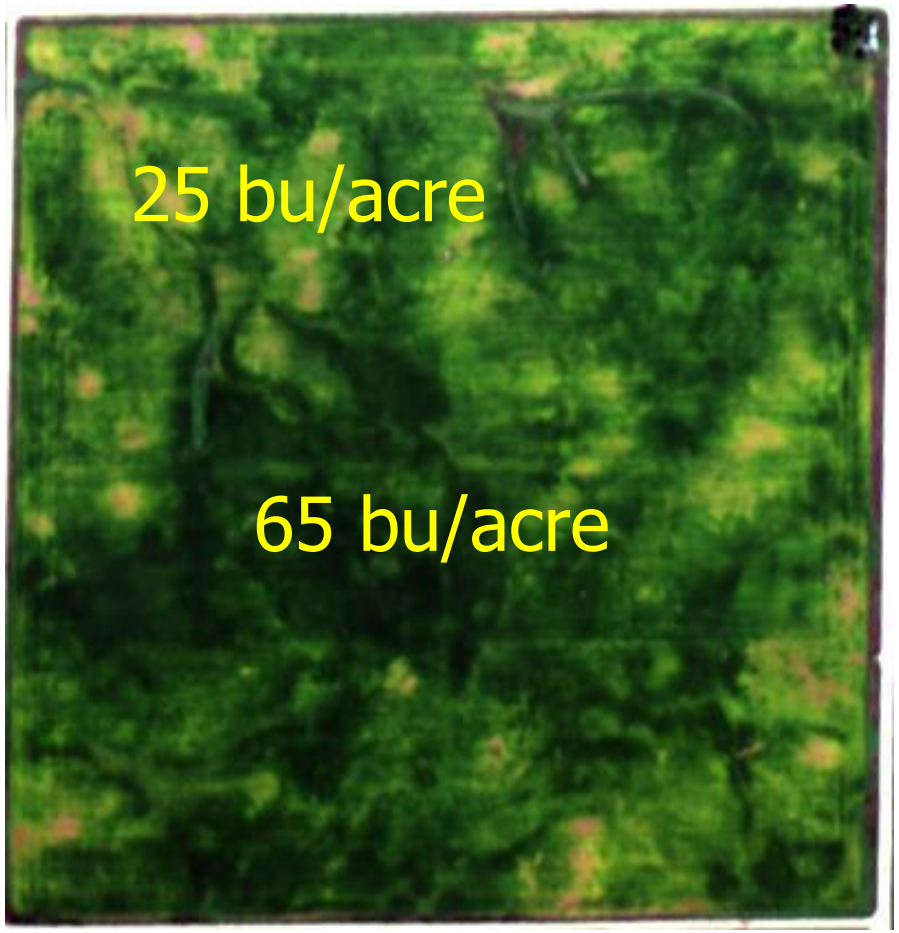
Soybean Production Field

Early August



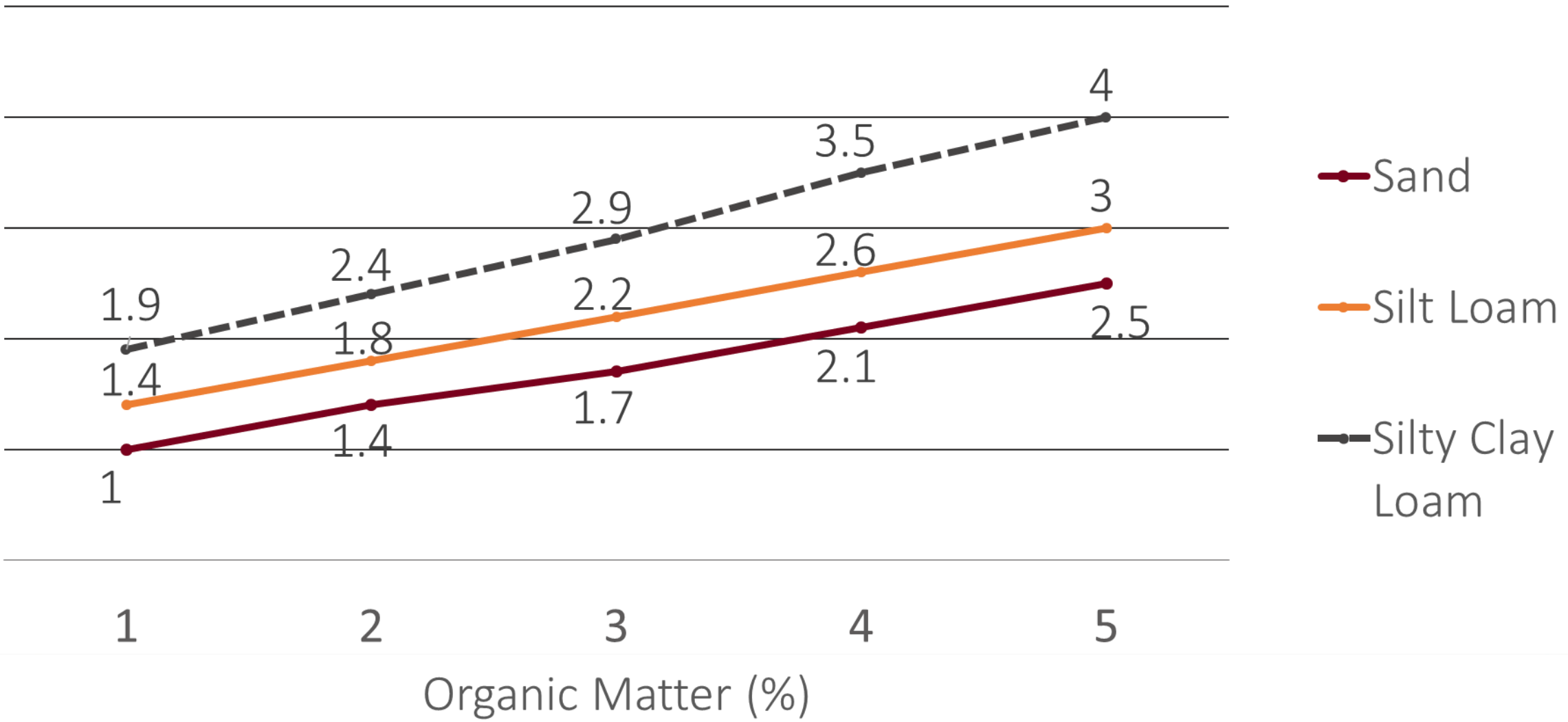
Yield variability comes from soils inability to supply water during grain-filling

Late August



Jerry Hatfield, USDA-ARS

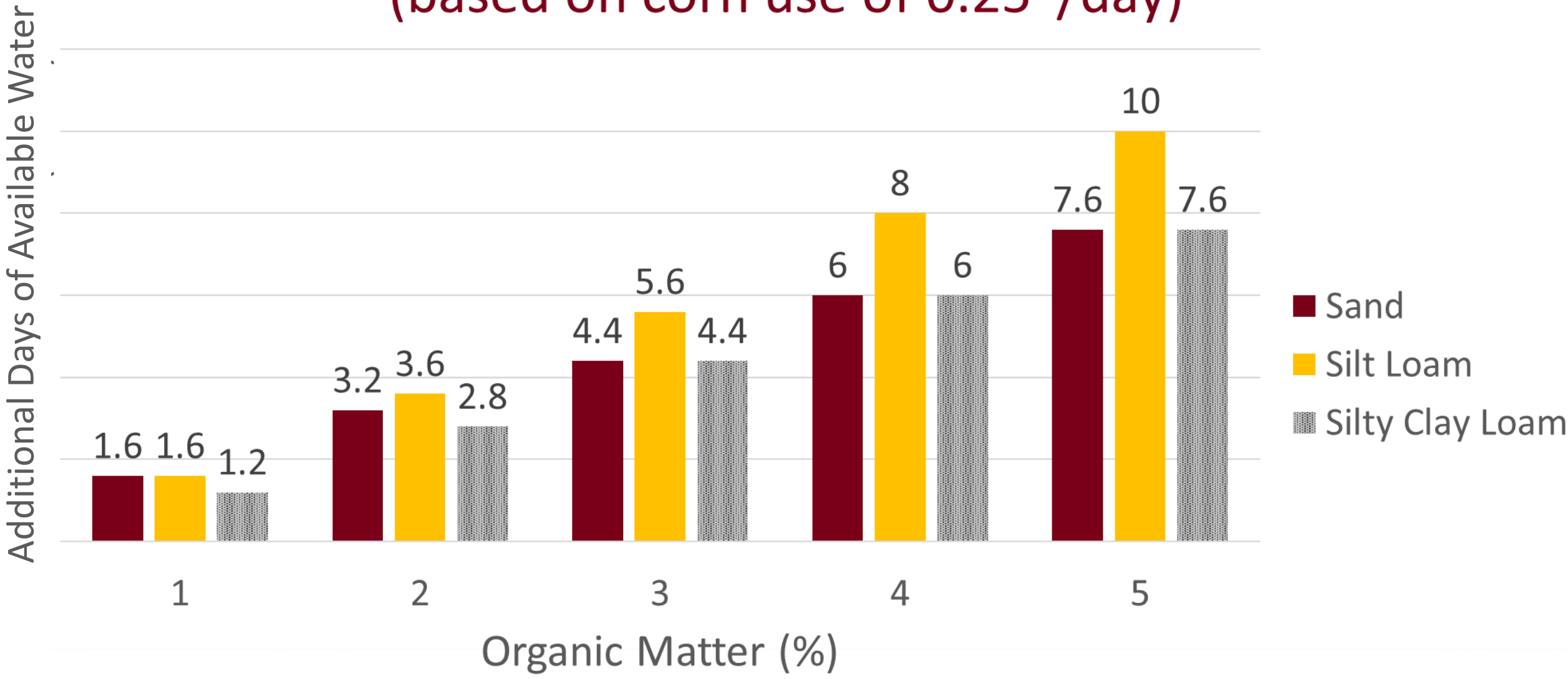
Available Water Content (Inches)



Hudson, 1994

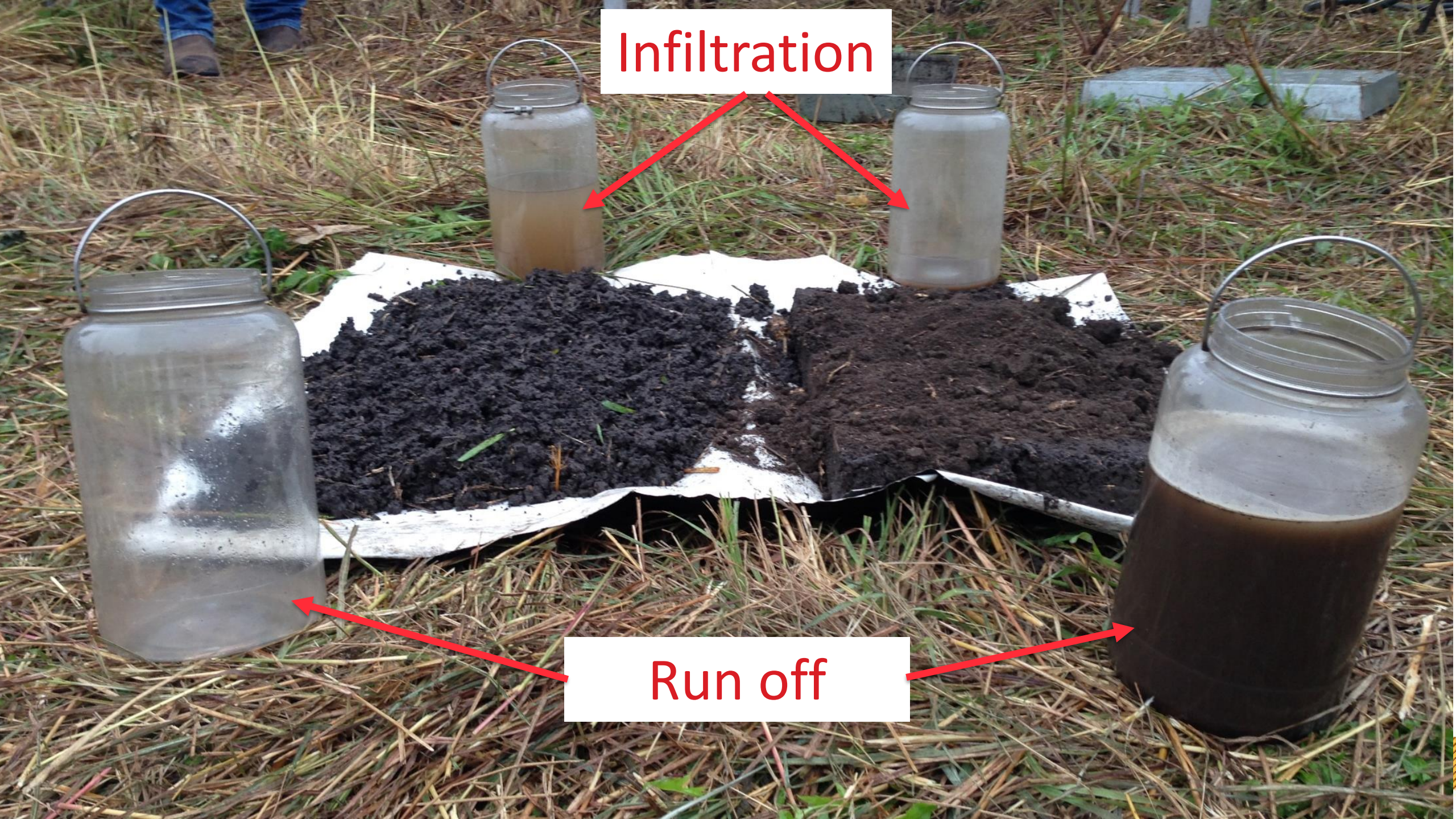
Additional Days of Available Water Content

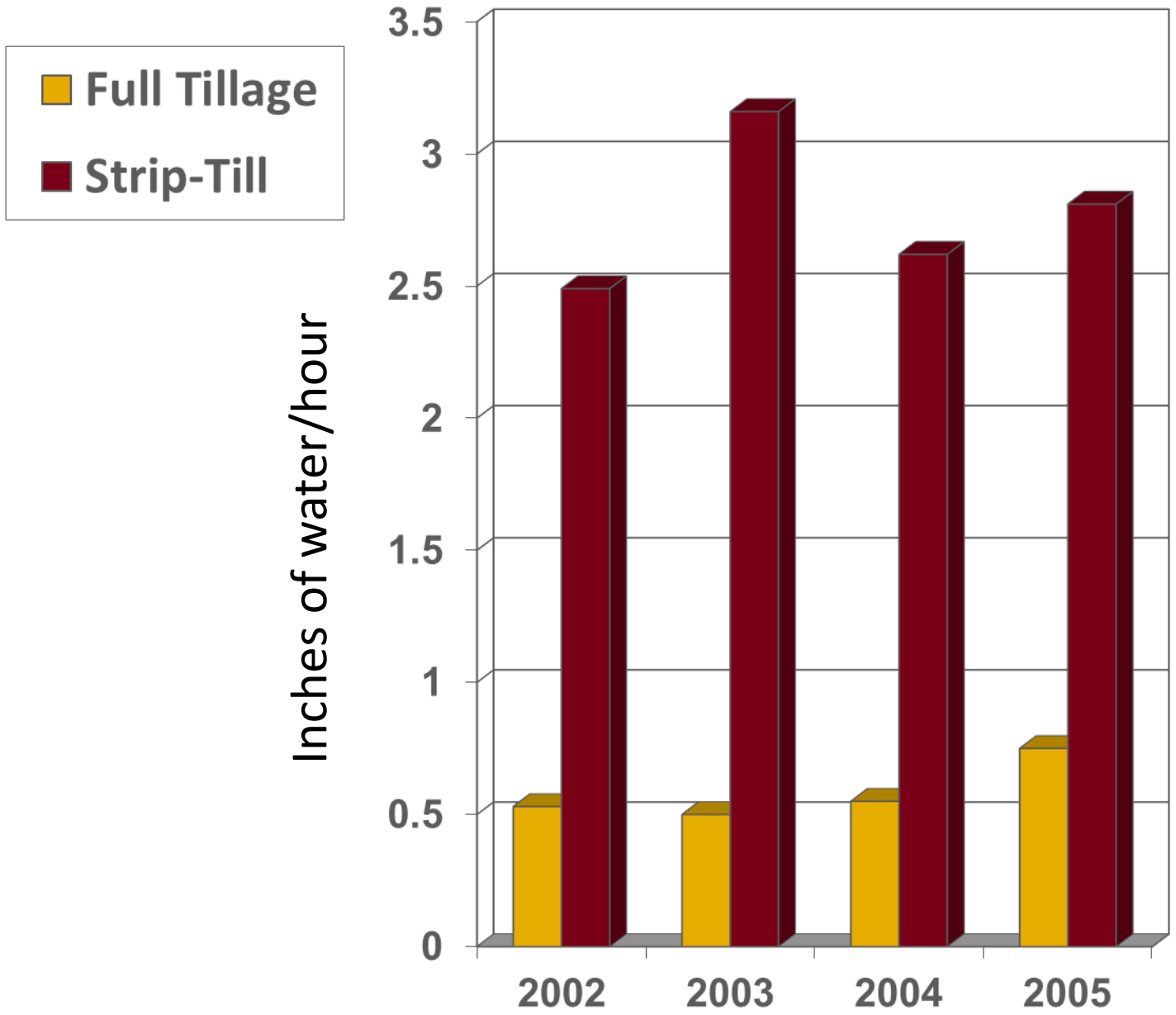
(based on corn use of 0.25”/day)



Hudson, 1994

Water Infiltration


Infiltration
Run off



Less Tillage Improves Water Infiltration

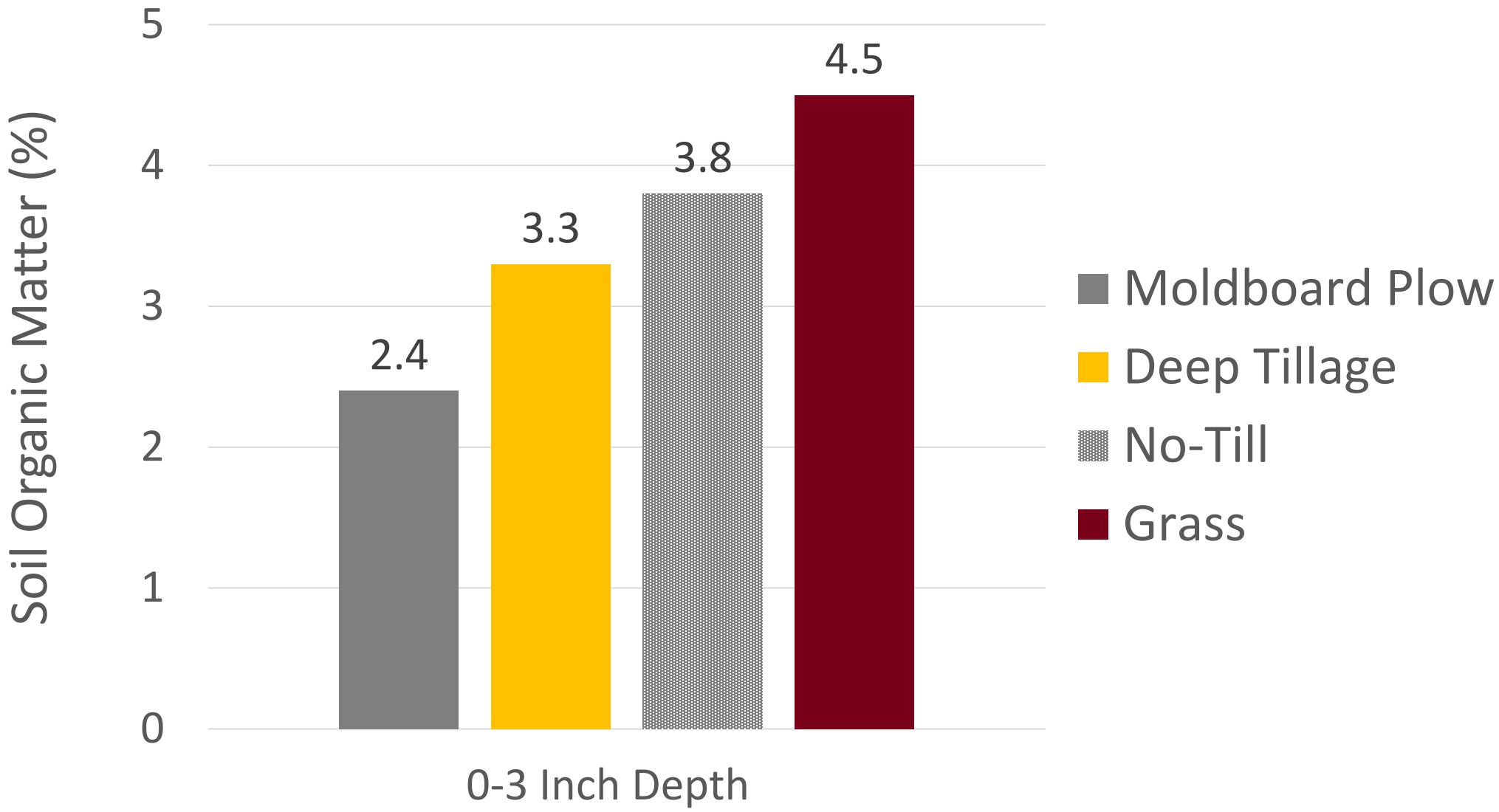
IRF – Irrigation Research Foundation – Yuma, CO Measurements with Cornell Sprinkle Infiltrometer on moist soil

Standing Residue Acts Like a Straw

Build Soil Organic Matter

- Reduce tillage (>40% residue cover)
- Crop rotation / cover crops
- Add organic inputs
  - compost
  - livestock and green manure
  - companion crops

Less Tillage = More Organic Matter

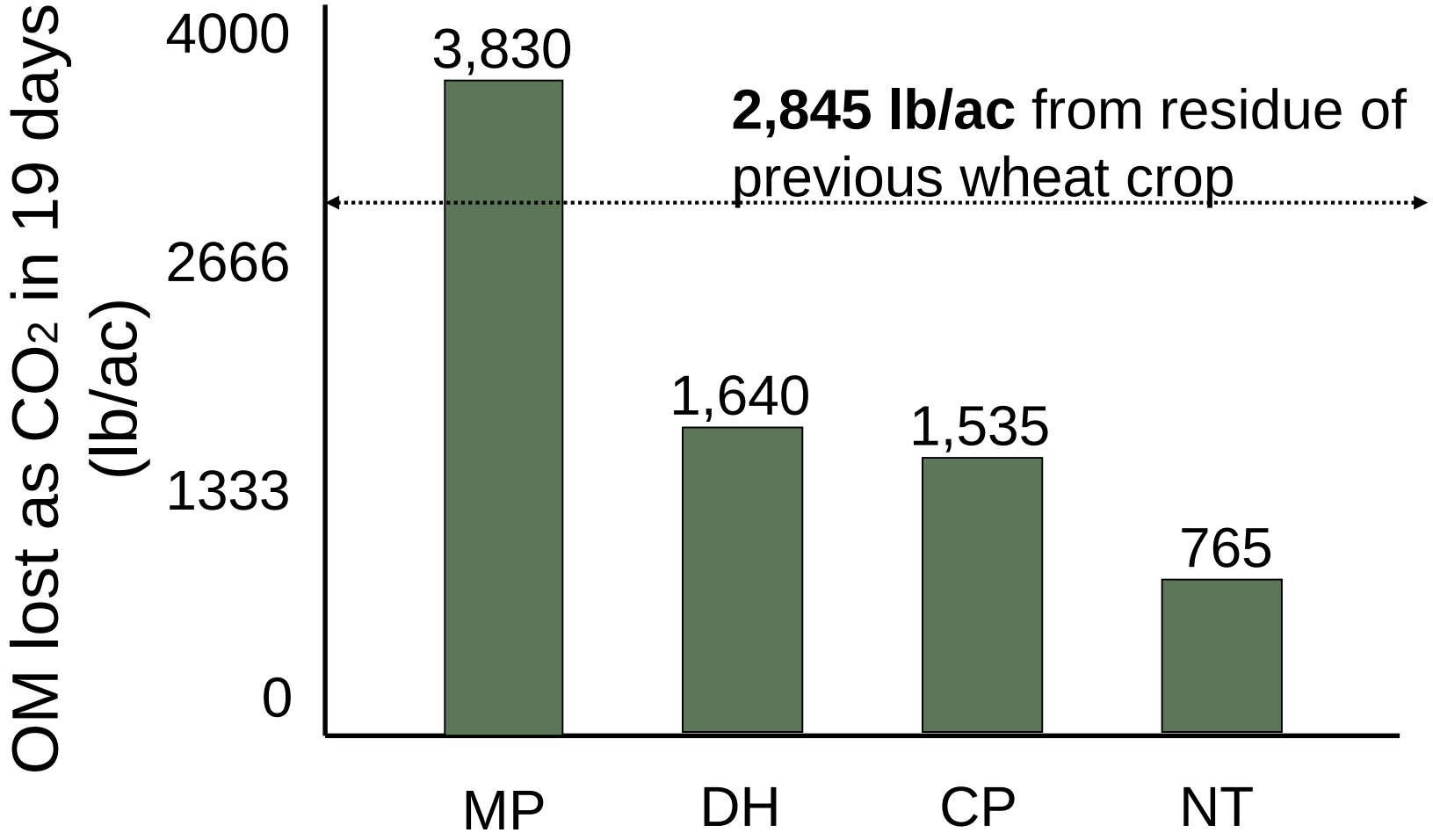


G. Hoyt, 2005

MR. GEM

ARS Morris, MN

Tillage-Carbon Study



Reicosky and Lindstrom, 1993

Nutrients in Organic Matter

Nitrogen:	1,000 lbs x .45/lb	$450
Phosphorus:	100 lbs x .38/lb	$ 38
Potassium:	100 lbs x .30/lb	$ 30
Sulfur:	100 lbs x .42/lb	$ 42
Carbon:	10,000 lbs	$ 0

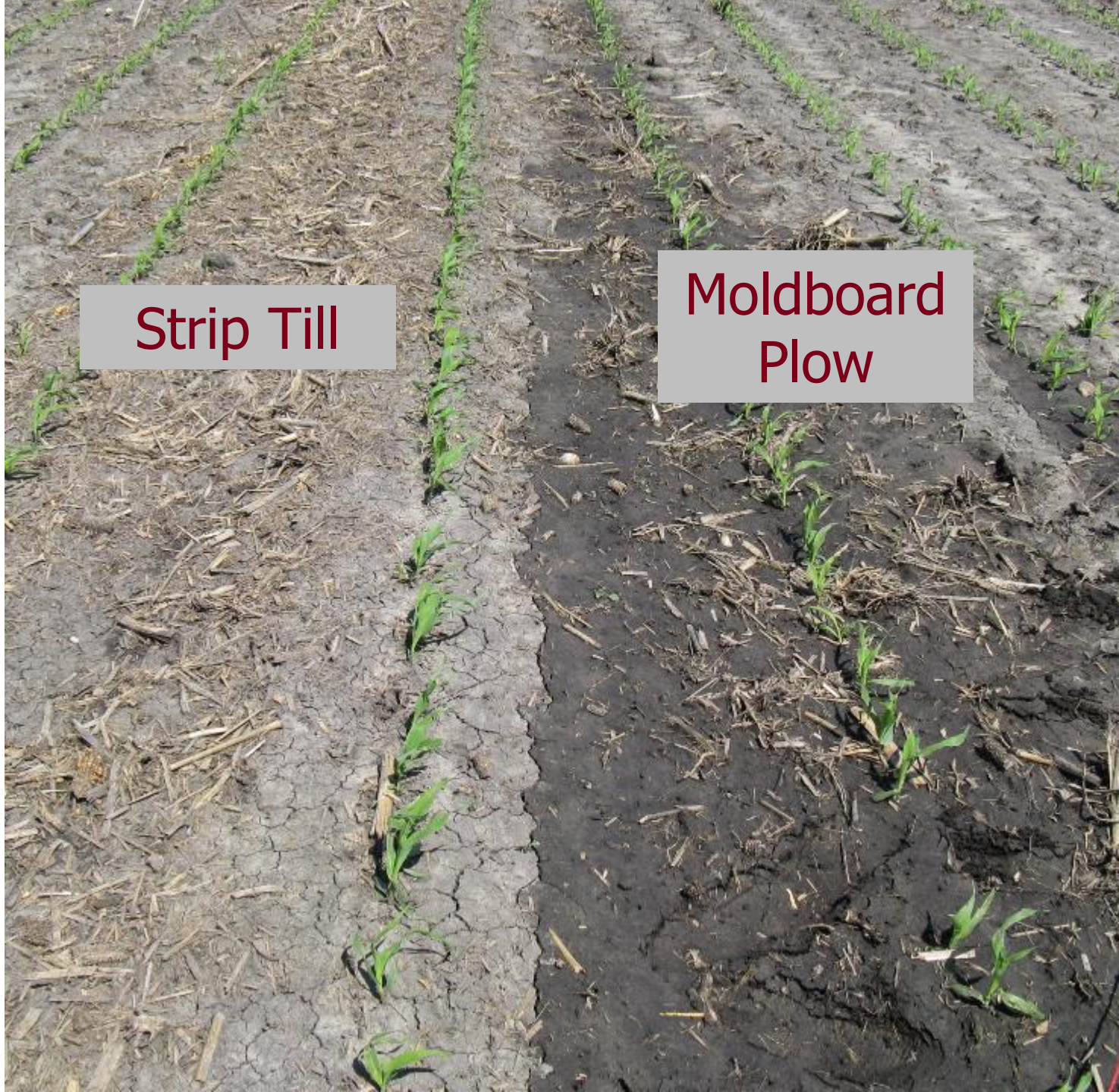
Value of 1% SOM Nutrients/Acre **~$560**

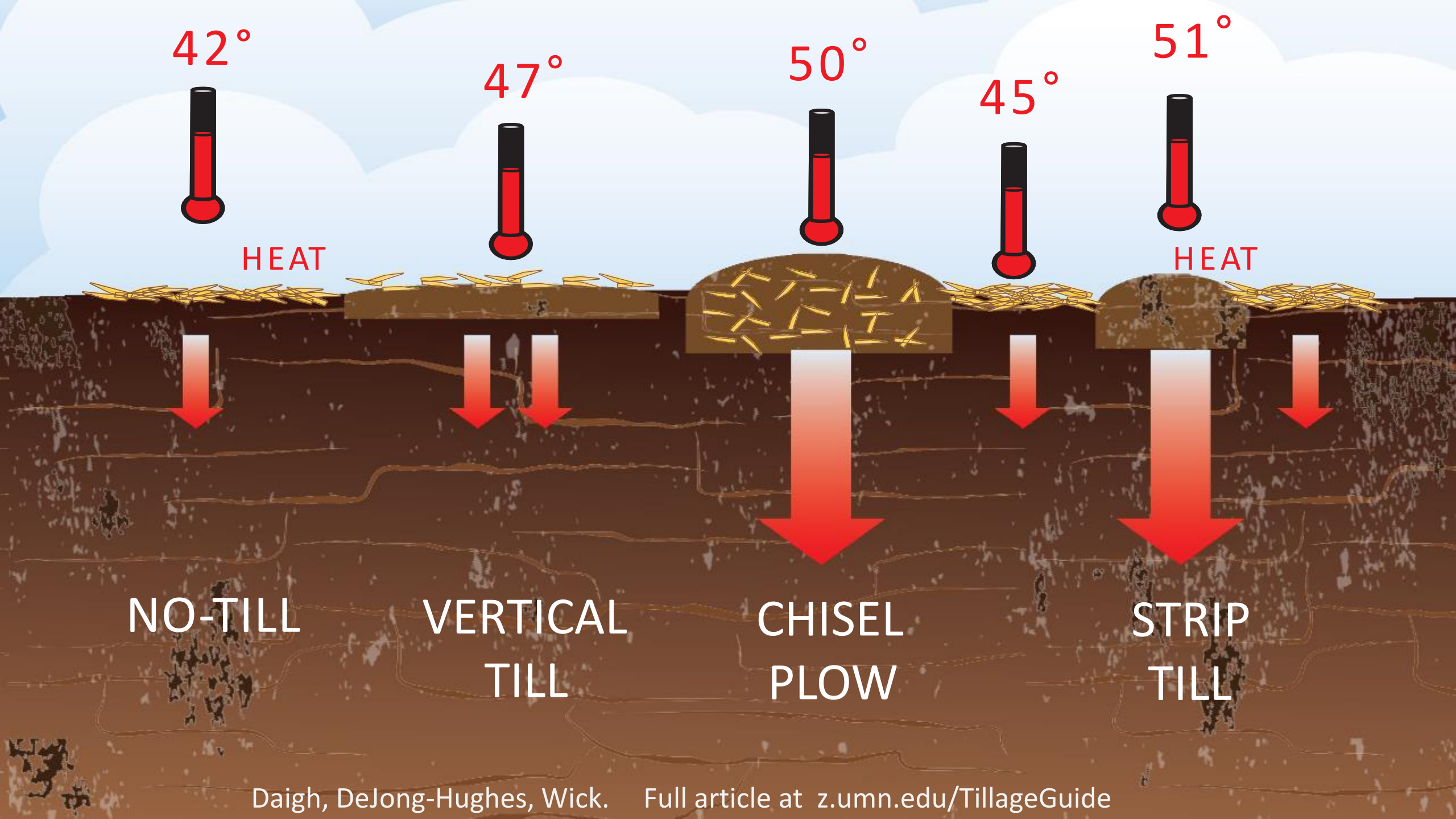
Assumptions:

2,000,000 lbs. soil in top 6 inches. 1% organic matter = 20,000 lbs.

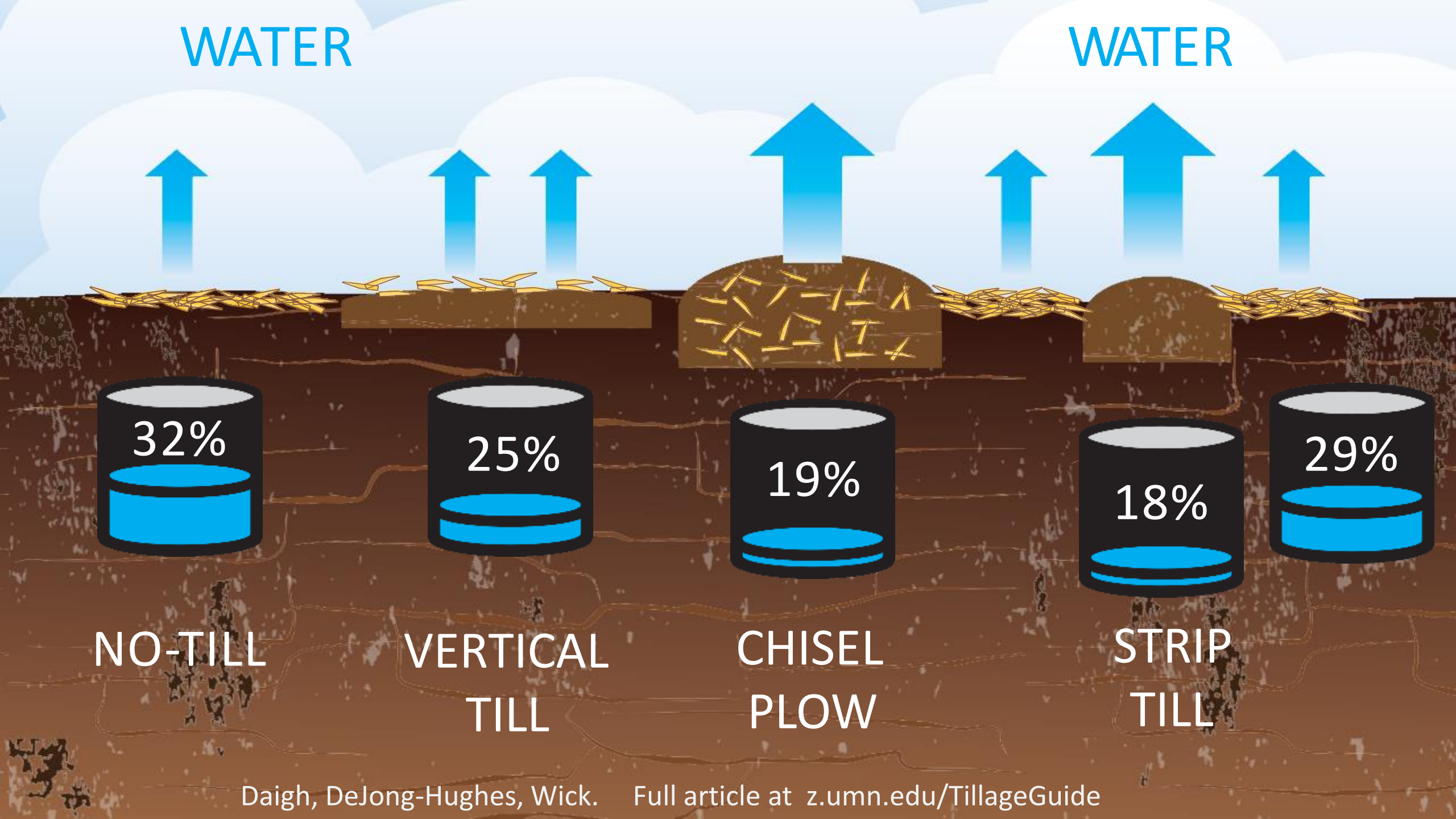
True of False?

Reduced till fields won’t warm-up or dry in time for early planting





Daigh, DeJong-Hughes, Wick. Full article at z.umn.edu/TillageGuide



Daigh, DeJong-Hughes, Wick. Full article at z.umn.edu/TillageGuide

Denitrification in a Saturated Soil

Destroy Soil Organic Matter

- **Tillage** (recreational, aggressive)
- **Erosion**
- No carbon inputs (ex. residue, cover crops, manure,…)
- Tight crop rotation

Why Worry About Soil Loss?

http://nrcca.cals.cornell.edu/soil/

Acceptable soil loss is

5T an acre per year

= 1 dime’s width

5T over 40 acres =

16 dump truck loads of soil!

Value of Topsoil

If you lost 5T/ac

Over 40 acres

At $25/T to replace

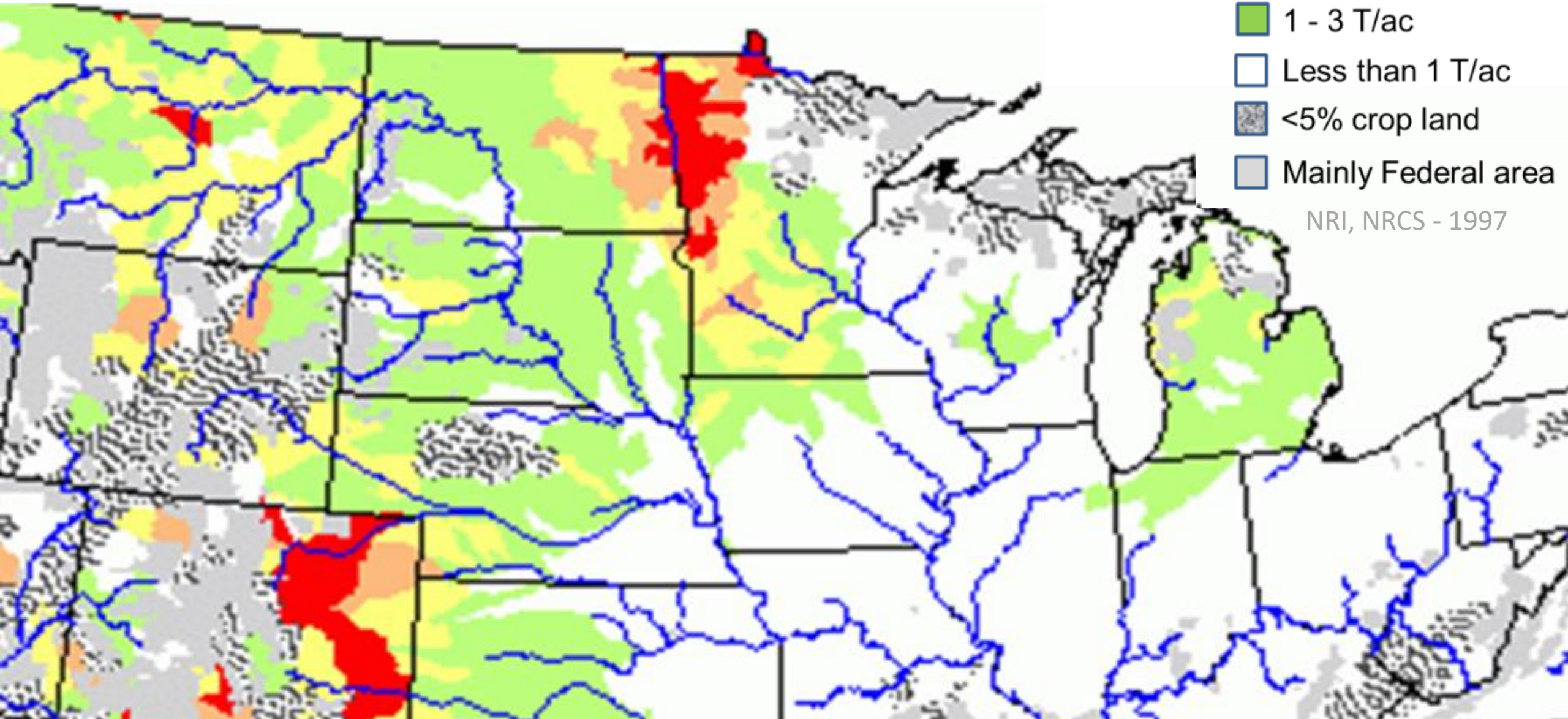
That's **$5,000**

Wind Erosion

occurs from wind speeds greater than 13 mph on smooth, wide, bare fields

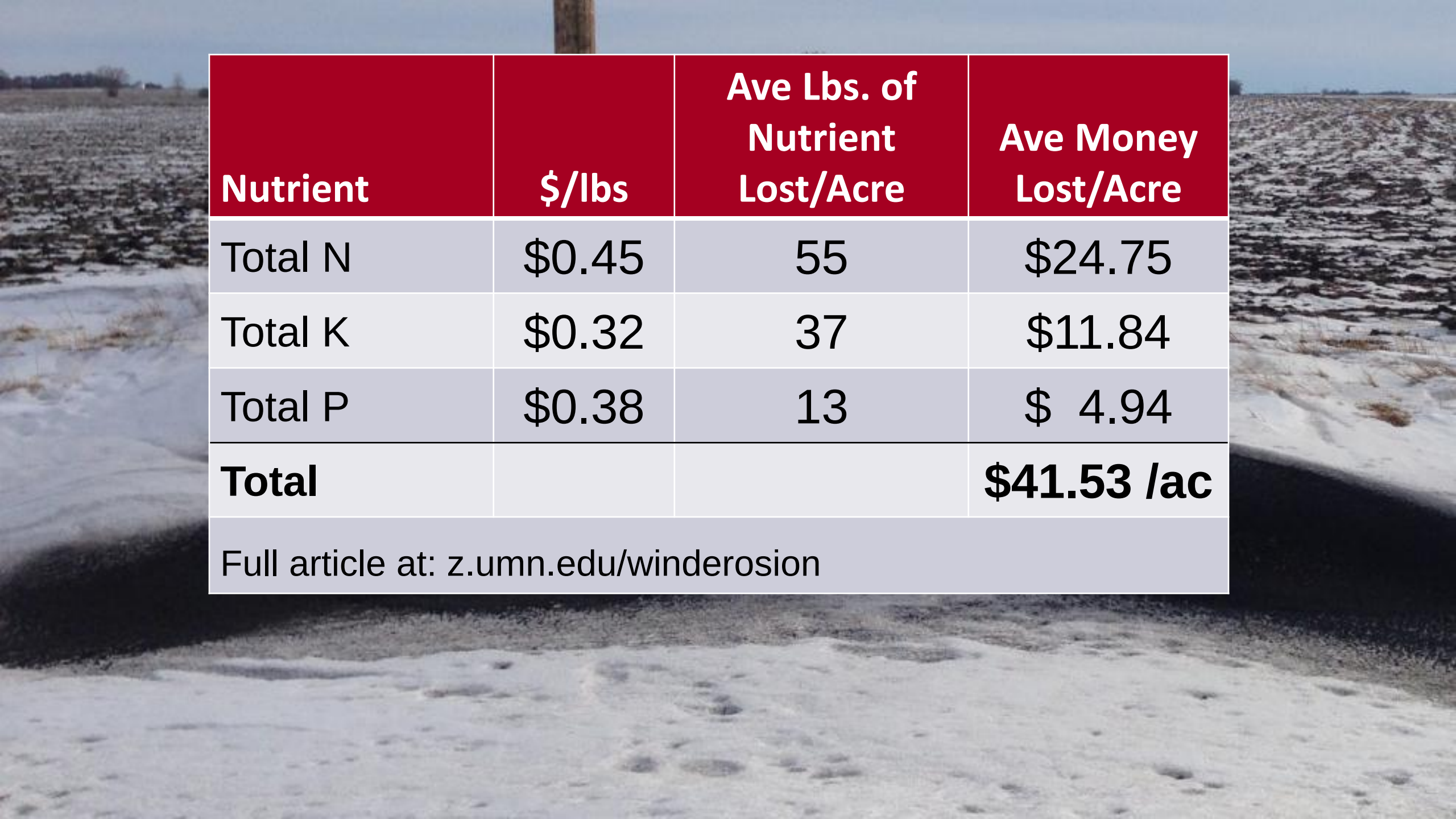
Photos: Dorian Gatchell

Average ***Annual*** Wind Erosion Loss



Soil Accumulation in 6 WC - MN Ditches

Low - 2 T/ac	**High -** 33 T/ac	**Average -** 9 T/ac



Nutrient	$/lbs	Ave Lbs. of Nutrient Lost/Acre	Ave Money Lost/Acre
Total N	$0.45	55	$24.75
Total K	$0.32	37	$11.84
Total P	$0.38	13	$ 4.94
Total			**$41.53 /ac**
Full article at: z.umn.edu/winderosion			

Average SCN Count in Three Ditch Soil Samples

7,150 (# eggs/100 cc)

Water Erosion

Photo: Dorian Gatchell

Washes away soil and nutrients


Let’s Talk About
Tillage Erosion

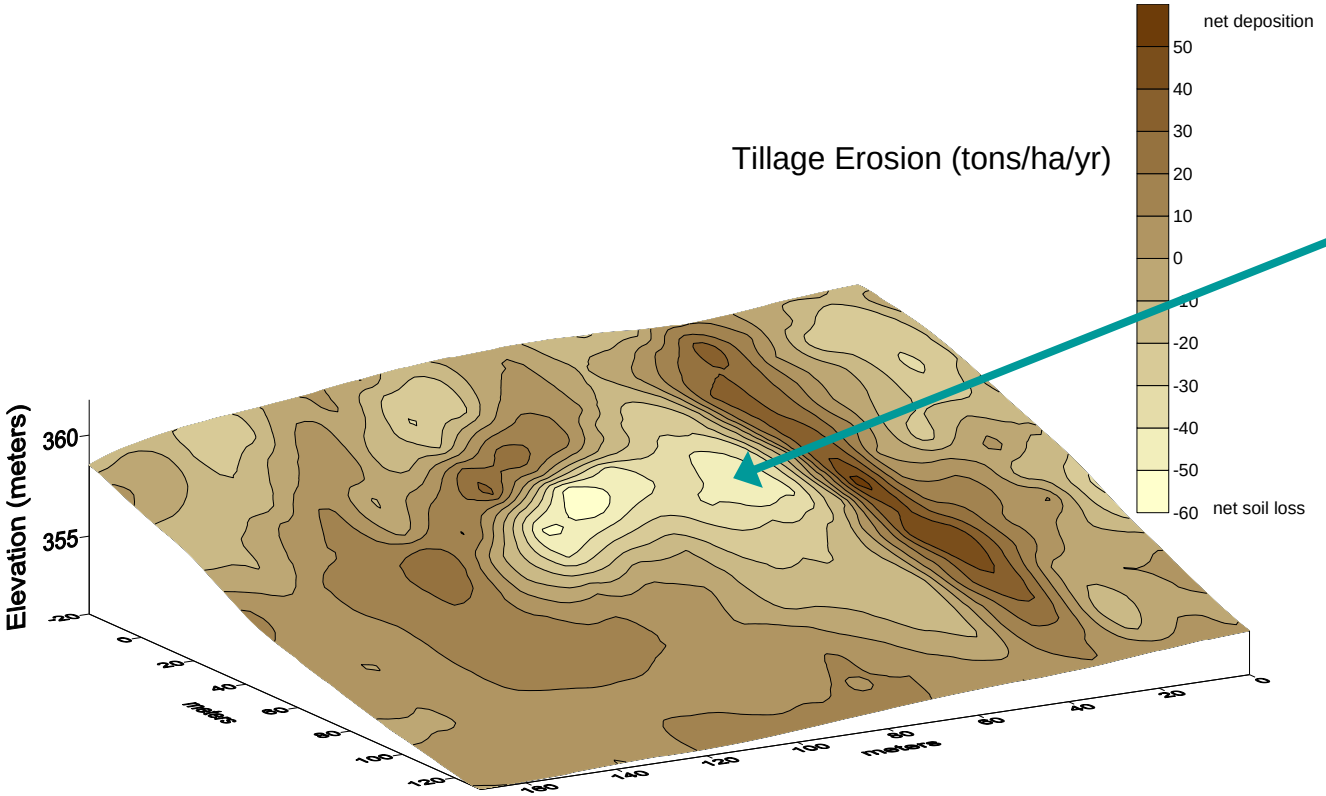
Tillage Moves Soil Up & Forward

Tillage Erosion Study W. Minnesota

Water, wind and tillage erosion

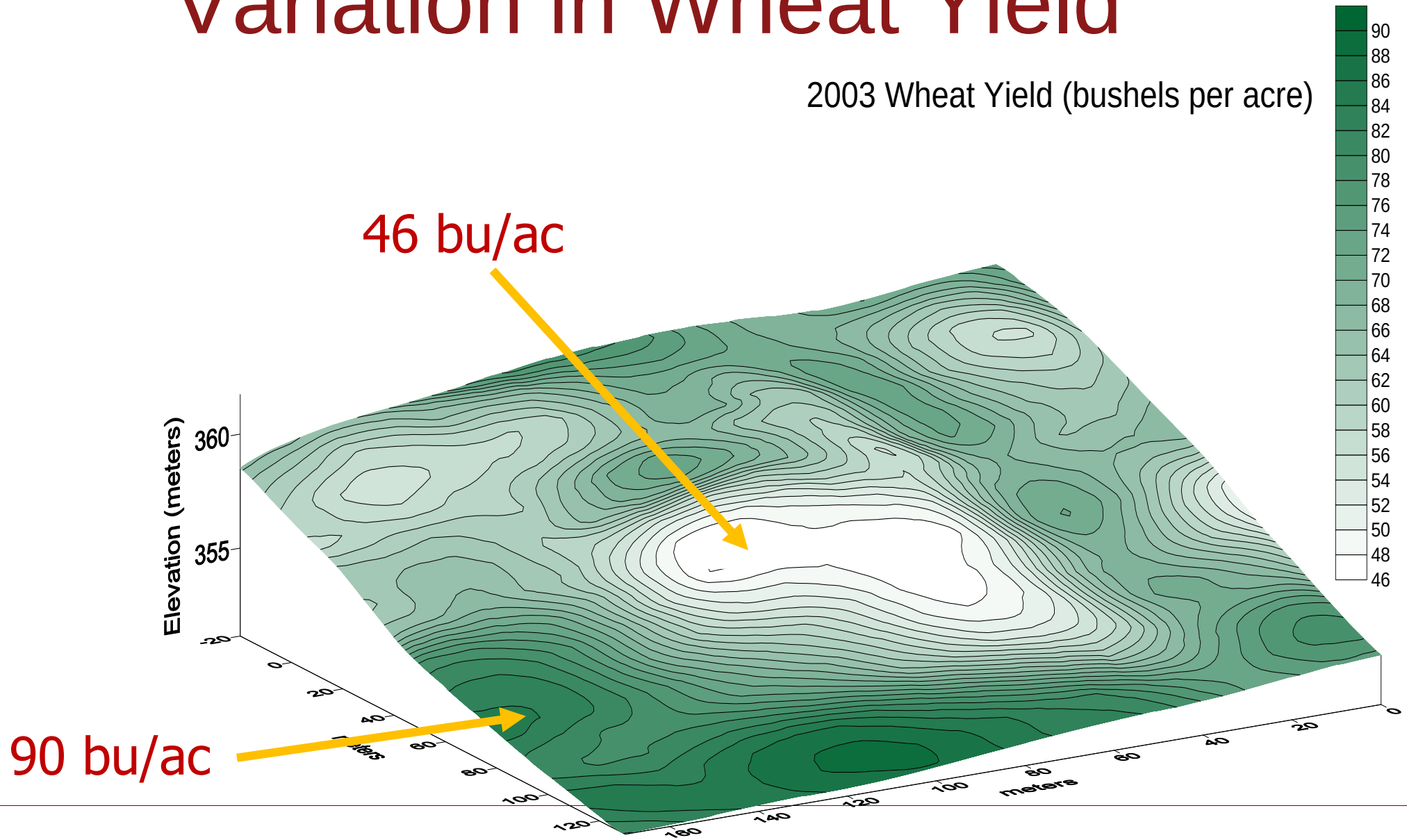
Long term MBP field

Lindstrom et al, USDA-ARS in Morris MN



Net soil loss by tillage erosion exceeded 27 T/ac/yr

Variation in Wheat Yield



Lindstrom et al, USDA-ARS in Morris

How Do You Manage This Much Variation?

	Subsoil	Topsoil
OM (%)	1.3	4.0
pH	7.3	8.4
P (ppm)	6	20
K (ppm)	115	175

How to Track Soil Health

Maryland Soil Quality Assessment

www.nrcs.usda.gov/

Field Notes/Inputs

Farm I.D. _____

Field I.D. _____ Date _____

Crop _____ Acres _____

Inputs

	Type	*Quantity*	*Price*
Fertilizer			
Manure			
Cover			
Crops			
Pesticides			
Other			
Equipment Used			

Problems, Comments, Weather Conditions

_____

_____

_____

Yields

Amount _____

Units _____

Moisture _____

Price _____

Scorecard Sheet

Date _____ Crop _____

Farm/Field ID _____

Soil Quality	**Poor**			**Fair**			**Good**		
Indicators	1	2	3	4	5	6	7	8	9
Water Infiltration									
Compaction									
Organic Matter Residue									
Soil Tilth and Structure									
Existing Crop									
Salinity									
Soil Color									
Root Structure									
Earthworms									
Other (Write in)									
Other (Write in)									

Indicator Table

Indicator	Poor	Medium	Good
Earthworms	0-1 worms in shovelful of top foot of soil. No casts or holes.	2-10 in shovelful. Few casts, holes, or worms.	10+ in top foot of soil. Lots of casts and holes in tilled clods. Birds behind tillage.
Organic Matter Color	Topsoil color similar to subsoil color.	Surface color closer to subsoil color.	Topsoil clearly defined, darker than subsoil.
Organic Matter Roots/Residue	No visible residue or roots	Some residue few roots	Noticeable roots and residue
Subsurface Compaction	Wire breaks or bends when inserting flag.	Have to push hard, need fist to push flag in.	Flag goes in easily with fingers to twice the depth of plow layer.
Soil Tilth Mellowness Friability	Looks dead. Like brick or concrete, cloddy. Either blows apart or hard to pull drill through.	Somewhat cloddy, balls up, rough pulling seedbed.	Soil crumbles well, can slice through, like cutting butter. Spongy when you walk on it.
Erosion	Large gullies over 2 inches deep joined to others, thin or no topsoil, rapid run-off the color of soil.	Few rills or gullies, gullies up to two inches deep. Some swift runoff, colored water.	No gullies or rills, clear or no runoff.
Water Holding Capacity	Plant stress two days after a good rain.	Water runs out after a week or so.	Holds water for a long period of time without puddling.
Drainage, Infiltration	Water lays for a long time, evaporates more than drains, always very wet ground.	Water lays for short period of time, eventually drains.	No ponding, no runoff, water moves through soil steadily. Soil not too wet, not too dry.
Crop Condition (How well it grows)	Problem growing throughout season, poor growth, yellow or purple color.	Fair growth, spots in field different, medium green color.	Normal healthy dark green color, excellent growth all season, across field.
pH	Hard to correct for desired crop.	Easily correctable.	Proper pH for crop.
Nutrient Holding Capacity	Soil tests dropping with more fertilizer applied than crops used.	Little change or slow down trend.	Soil tests trending up in relation to fertilizer applied and crop harvested.

Need Multiple Samples in Each Field

- In the row versus between the row
- Soil type
- Wheel traffic
- Salt-affected areas
- Eroded hilltops
- Slope

Visual Assessment

- Look for residue > 40%
- Water infiltration
- Crusting
- Ponded water

Stop the erosion!

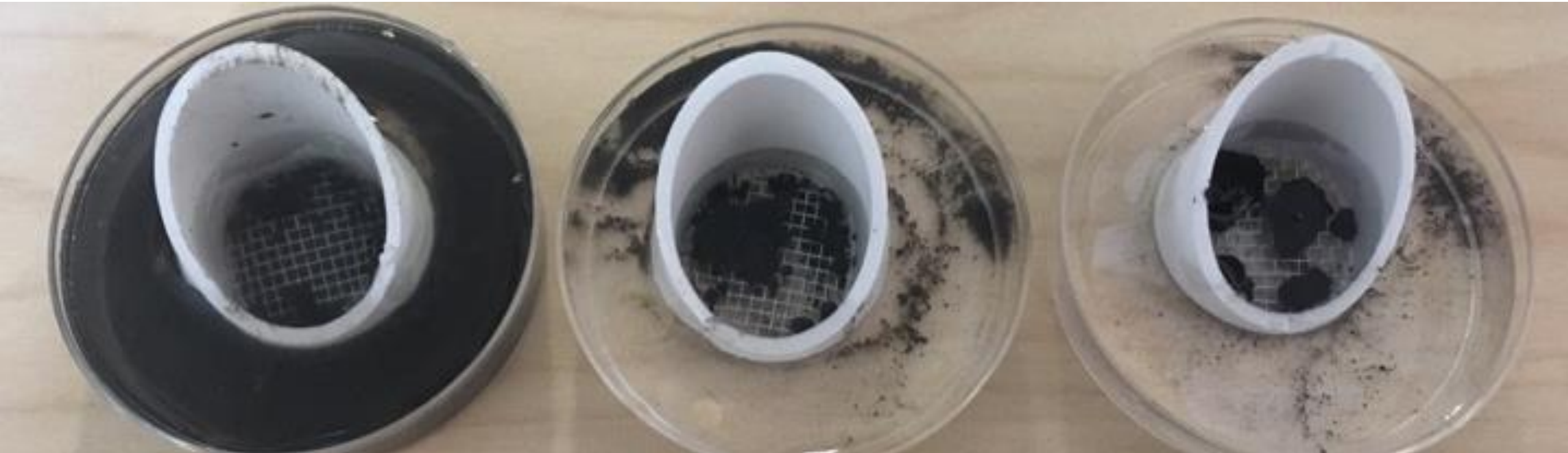
Shovel Assessment

- How easy is it to shovel the soil
- Look at the structure
  - Muddy, sticky, …
- Smell
- Root growth

Physical Assessment

- Aggregation, slaking
- Penetration resistance
- Infiltration

Interpreting Indicators of Rangeland Health, 2005, Dept. of Interior



Biological Assessment

- Many tests to rate your soil's health
- Active Carbon Fraction

http://archive.sltrib.com/article

Haney and Solvita Tests – UMN Findings

- Solvita ‘falls apart’ by 3% OM
- Haney over estimates K needs
- Haney under estimates P needs
- Soil texture changes results

www.extension.umn.edu/agriculture/soils/soil-properties/haney-soil-test/

Summary

- Tillage costs money ($20/ac)
- Wear and tear on equipment
- Increases soil erosion (3 - 20 T/ac)
- Lost soil costs money ($25 per ton)

Cost per acre = $95+

Summary

- Lost organic matter
  - less water to grow crops (lose 1-4 days of crop moisture)
  - less nutrients for crops ($560 in 1% OM)

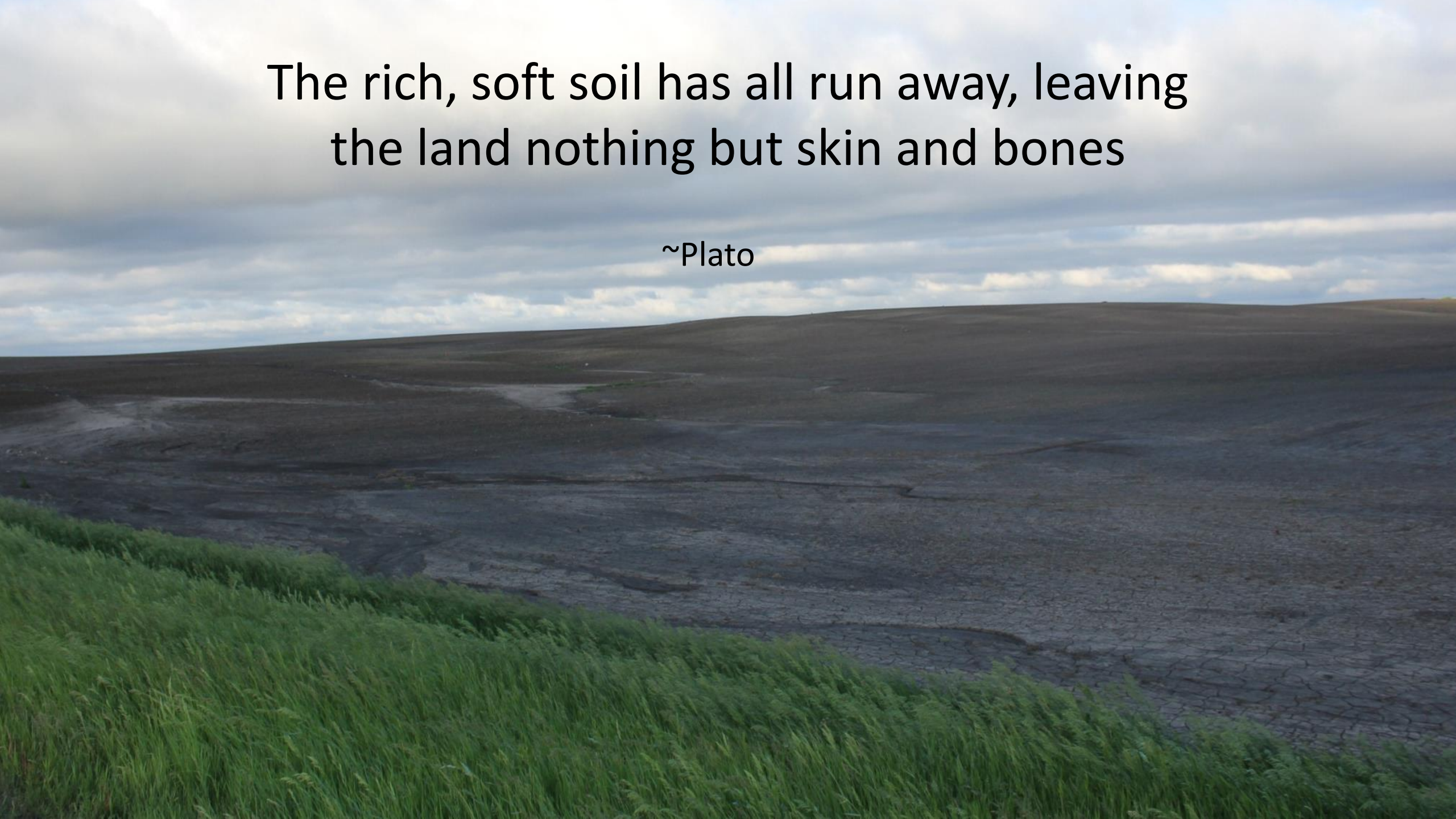
- Less water and nutrients = lowers yields and more fertilizer needed

Summary

- Denitrification (2-4 #/day)
- Field variability and resiliency is affected

Bottom Line

You help manage this resource


The rich, soft soil has all run away, leaving the land nothing but skin and bones
~Plato

Questions?

DIGtheCTC.com Dec 18-19, Fargo, ND

extension.umn.edu/agriculture/soils

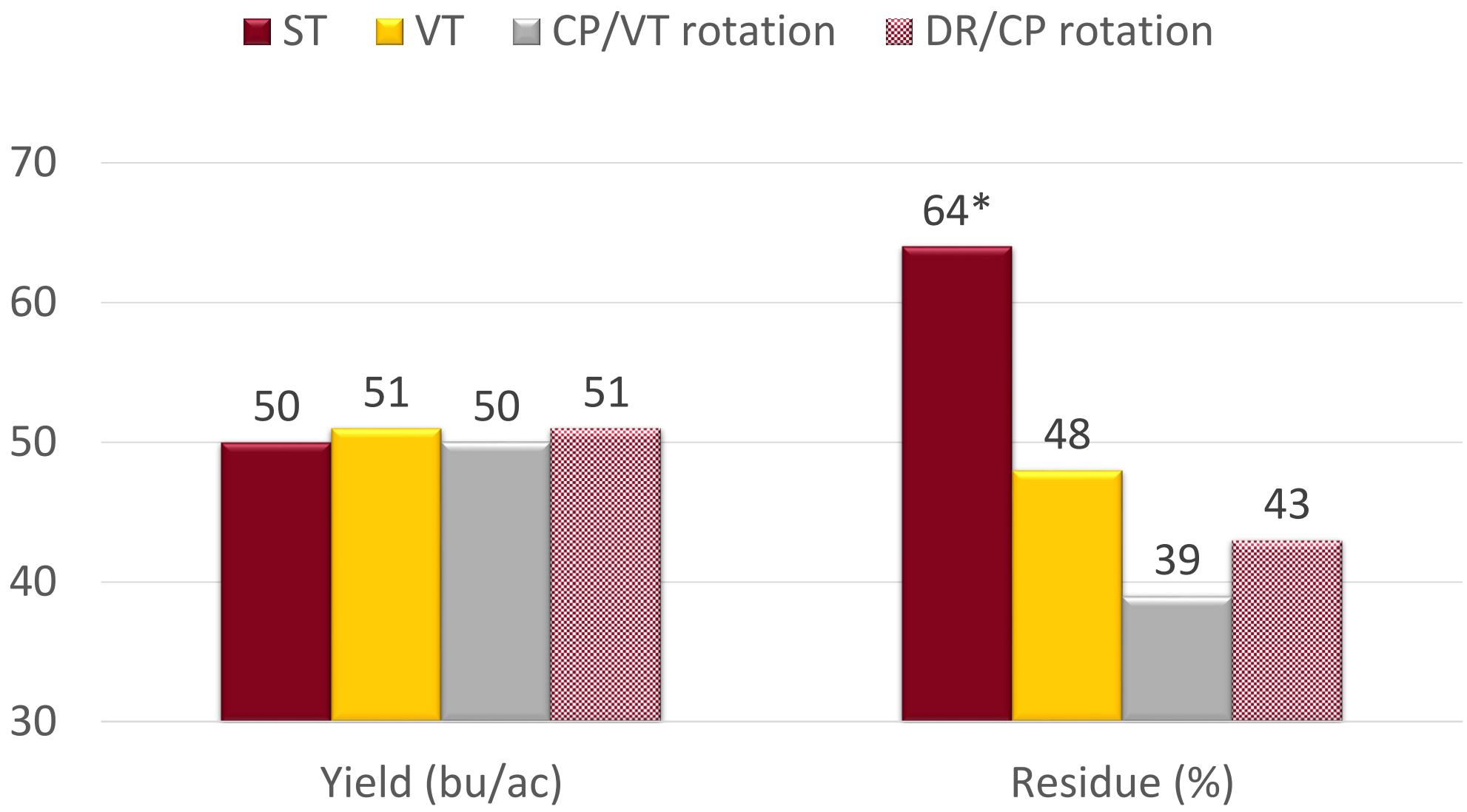
dejon003@umn.edu

Twitter - @dejon003

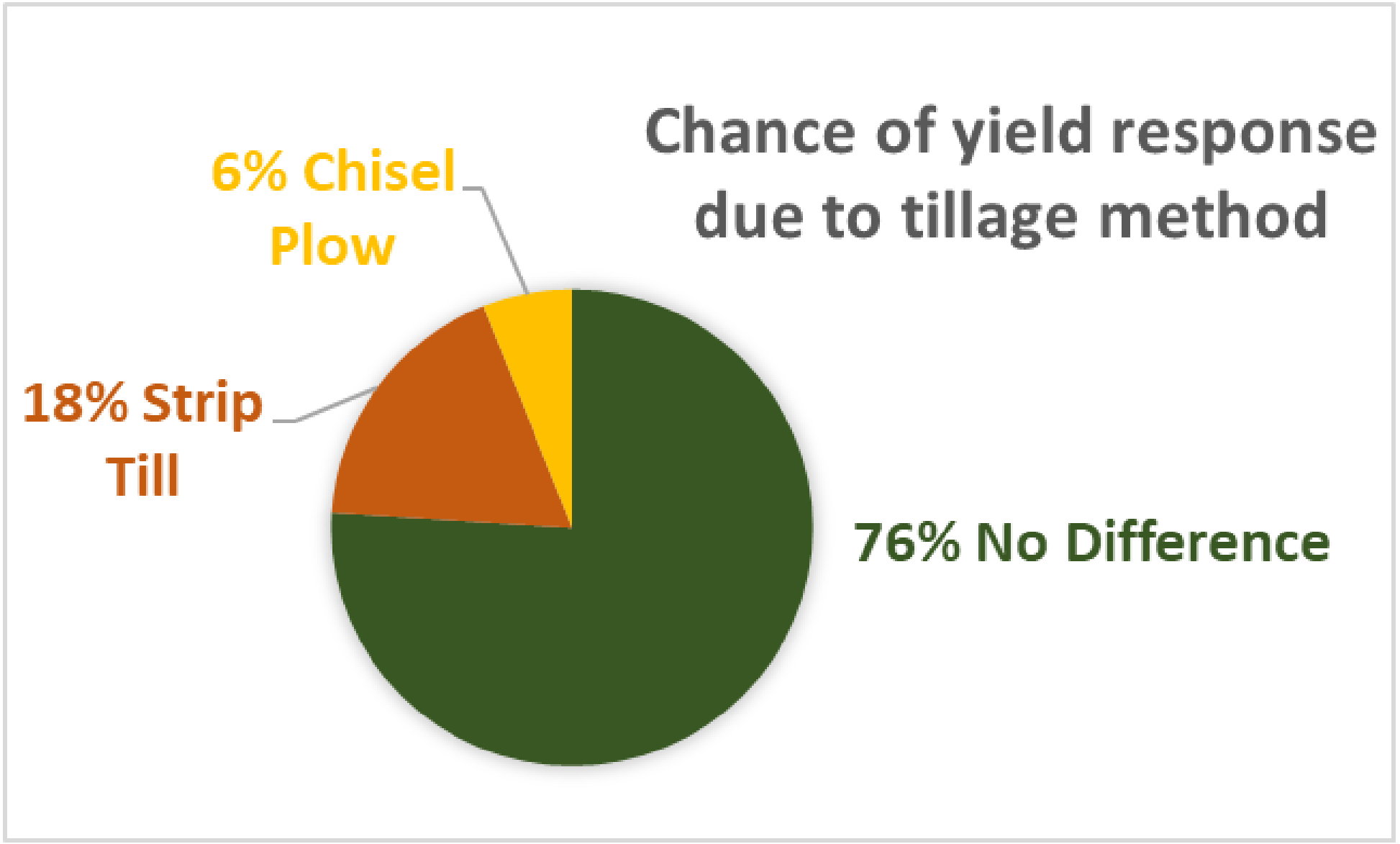
True or False?

Crops need deep tillage or yields will suffer

3 Year Average Soybean Yield and Soil Residue (2010-12)

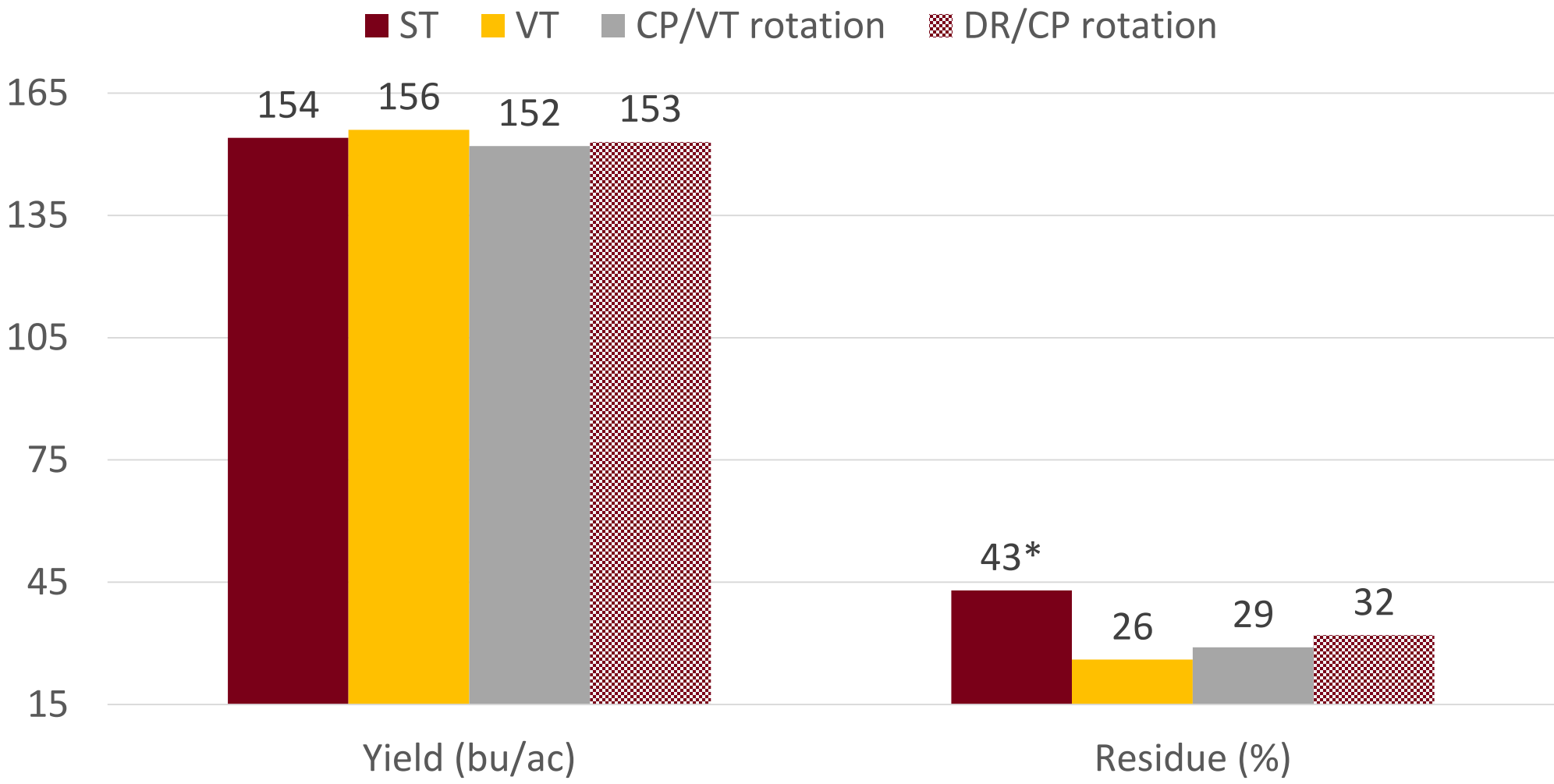


* Yields are not statistically different from each other. Residue was significantly different with an LSD (0.10) = 7.

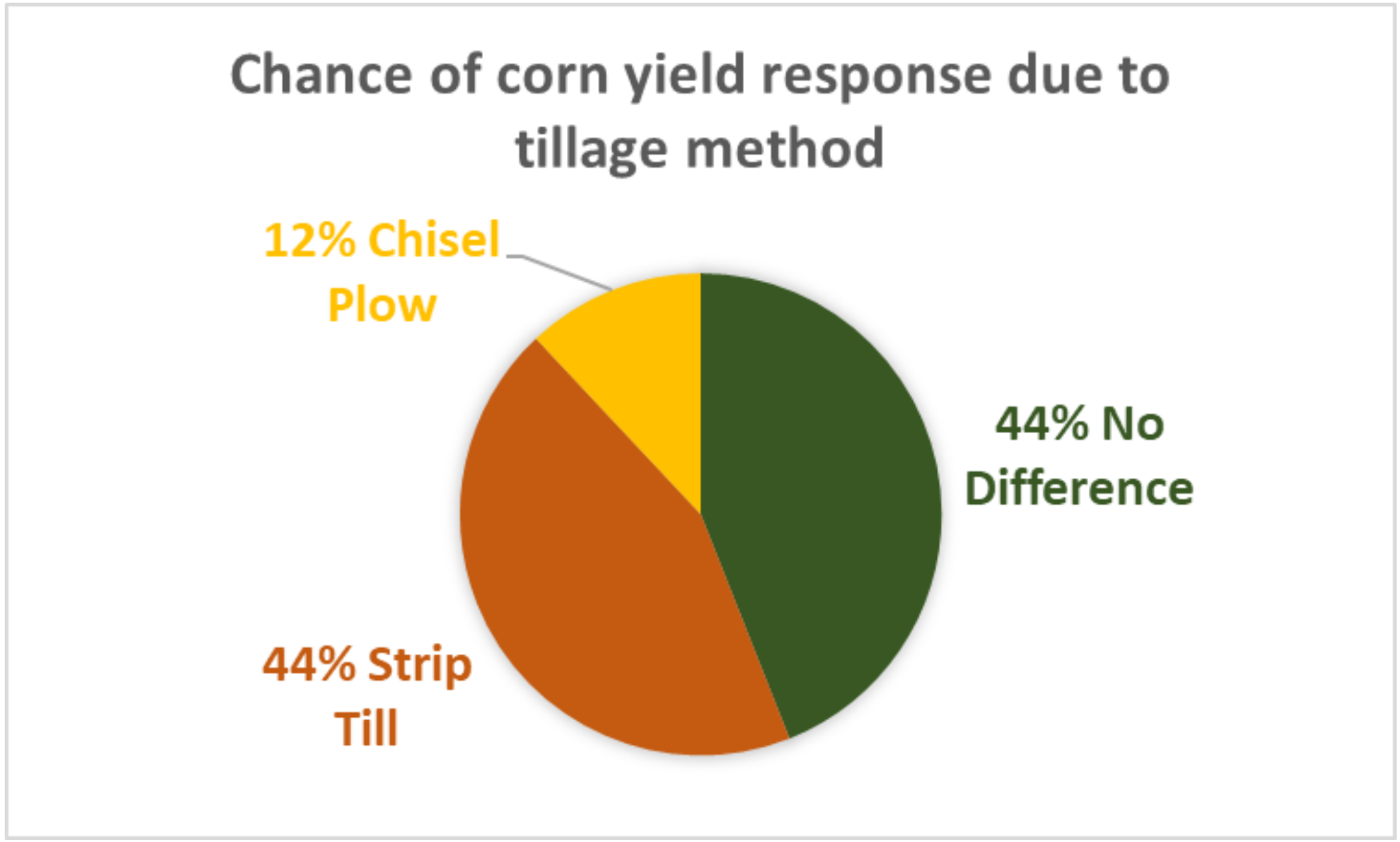


Soybean yield response to tillage for 17 site years in E. North Dakota and NW Minnesota (2005 – 2012)

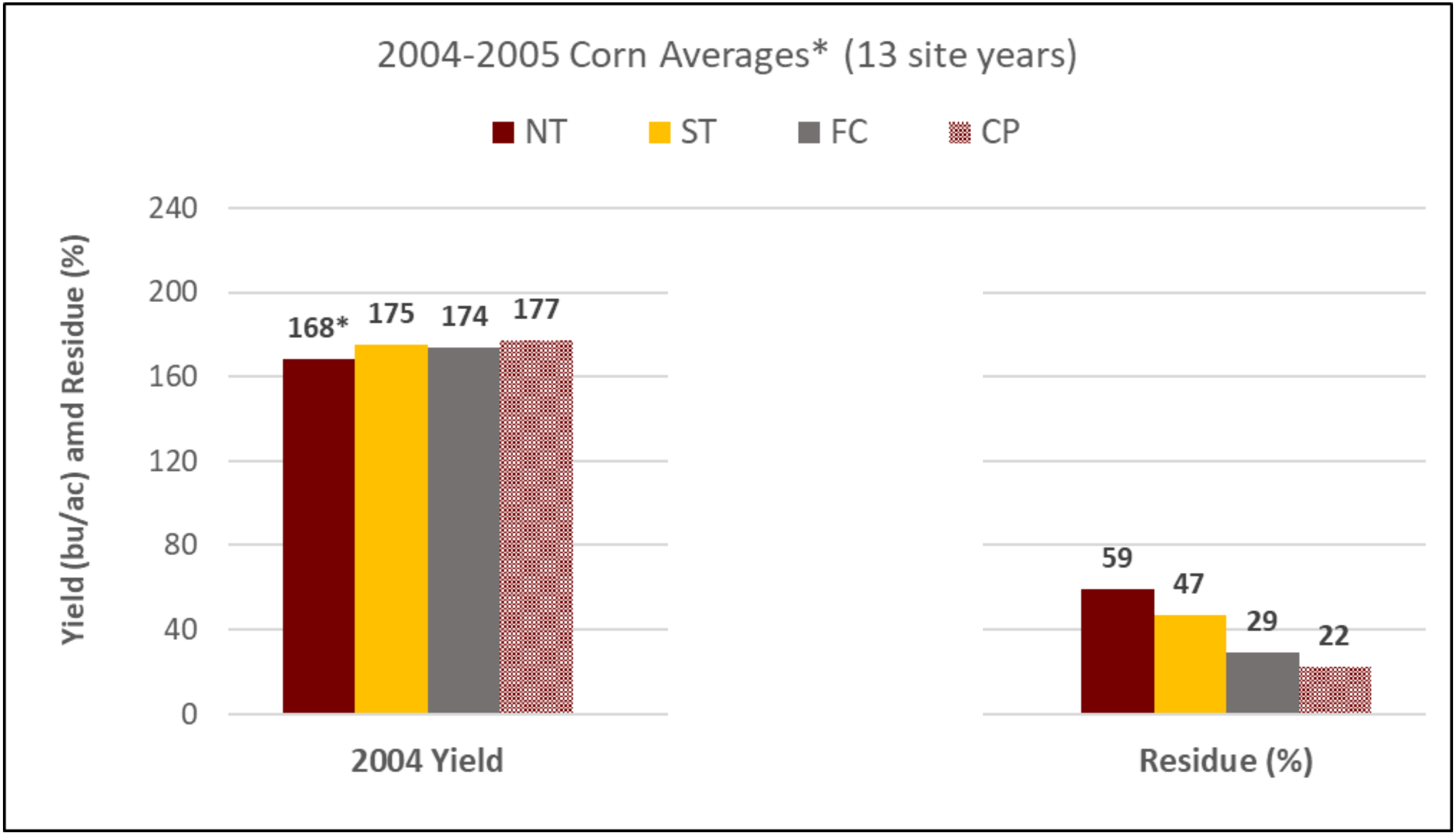
3 Year Average Corn Yield and Soil Residue (2010-12)



* Yields are not statistically different from each other. Residue was statistically different with an LSD (0.10) = 4.



Corn yield response to tillage for 18 site years across E. North Dakota and NW Minnesota through 2005 - 2012.


2004-2005 Corn Averages* (13 site years)
NT
ST
FC
CP
Yield (bu/ac) amd Residue (%)
240
200
160
120
80
40
0
168*
175
174
177
59
47
29
22
2004 Yield
Residue (%)

True or False

Economics favor full tillage

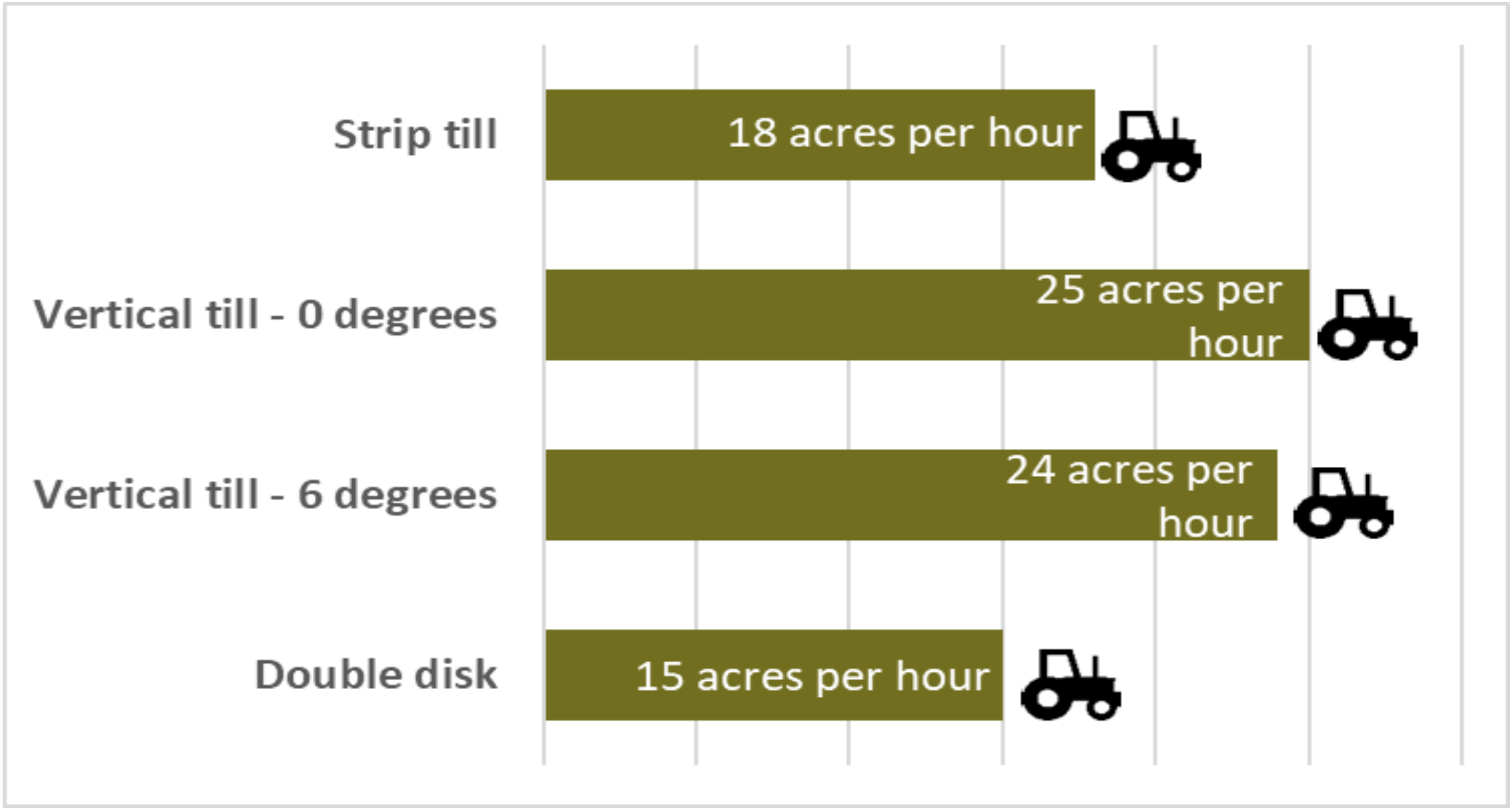
	Tillage Options When Planting Soybeans (costs/acre)			
	No-till	Vertical Till or Field Cultivation	Chisel Plow + Field Cultivation	Strip Till
Planter (tillage specific)	$20.15	$19.90	$19.90	$20.15
Primary Tillage	$0	$14.05	$16.45	$17.15
Secondary Tillage	$0	$0	$14.05	$0
Combine	$34.75	$34.75	$34.75	$34.75
TOTAL	**$54.90**	**$68.70**	**$85.15**	**$72.05**
# of passes	2	3	4	3

	Tillage Options When Planting Corn (cost/acre)			
	Strip Till	Chisel Plow + Field Cultivation	Disk Rip + Field Cultivation	Moldboard Plow + Field Cultivation
Planter	$20.15	$19.90	$19.90	$19.90
Side dress N fertilizer	$11.15	$0	$0	$0
Broadcast fertilizer	$0	$4.90	$4.90	$4.90
Anhydrous ammonia	$0	$12.20	$12.20	$12.20
Primary tillage pass	$17.15*	$16.45	$17.80	$18.80
Secondary tillage pass (1st pass)	$0	$14.05	$14.05	$14.05
Secondary tillage pass (2nd pass)	$0	$0	$0	$14.05
Combine w/o chopping head	$34.75	$0	$0	$0
Combine with chopping head	$0	$40.10	$40.10	$40.10
TOTAL	**$83.20**	**$107.60**	**$108.95**	**$124.00**
# of passes	4	6	6	7

Operation	Fuel Use (Gal/1,000 acre)
Shallow disking	35
Field cultivation	73
Strip till	175
Moldboard plow + 1 field cultivation	508
Moldboard plow + 2 field cultivations	581

Moldboard plowing with two passes of a spring field cultivator would use 546 gallons more diesel ($1,910) than a shallow disking and 406 gallons more diesel ($1,420) than strip till over 1,000 acres.

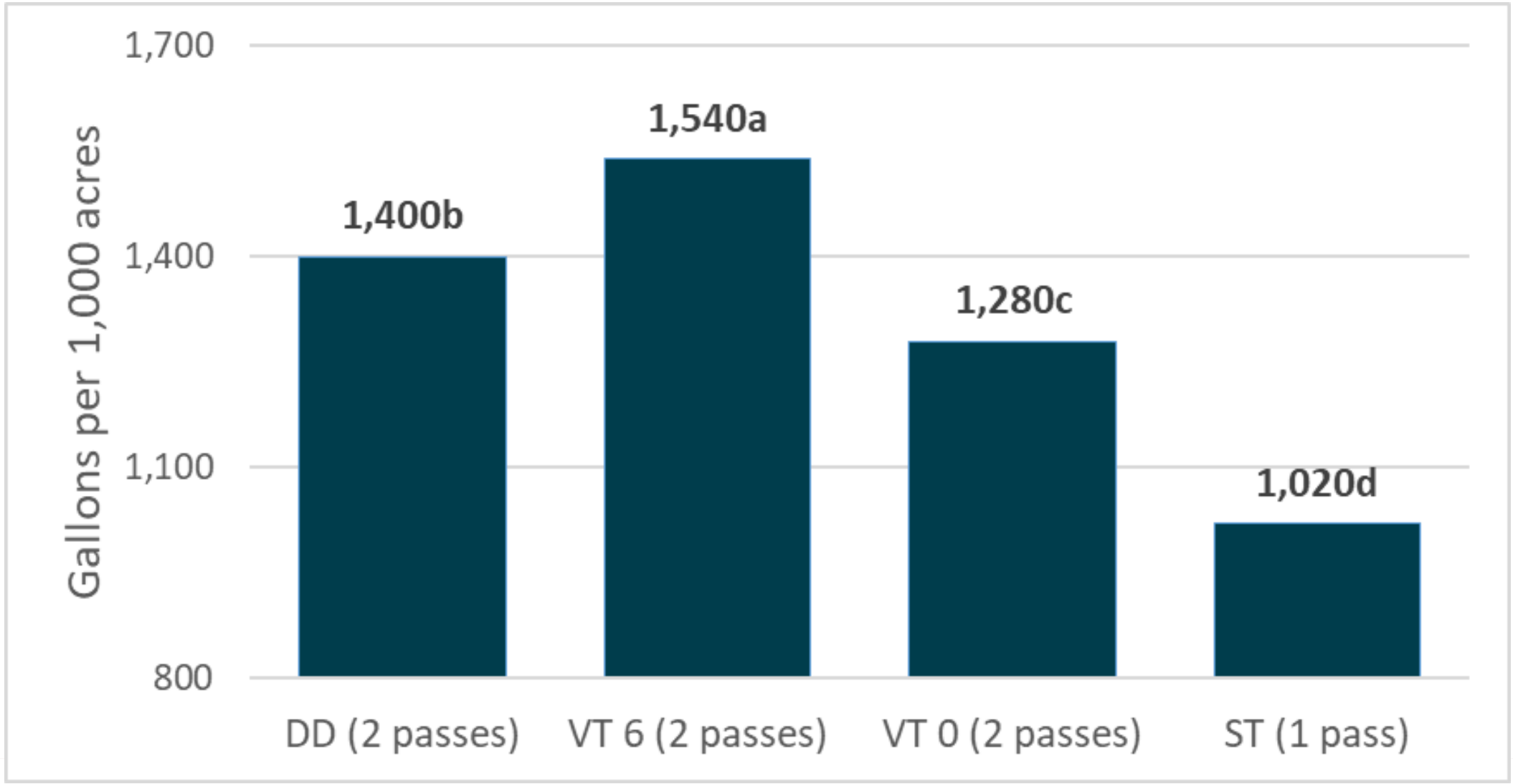
Adapted from Hanna and Schweitzer, ISU



All implements were pulled by the same tractor, on a sandy loam soil, in corn residue.
There were no differences in soybean yield due to tillage.

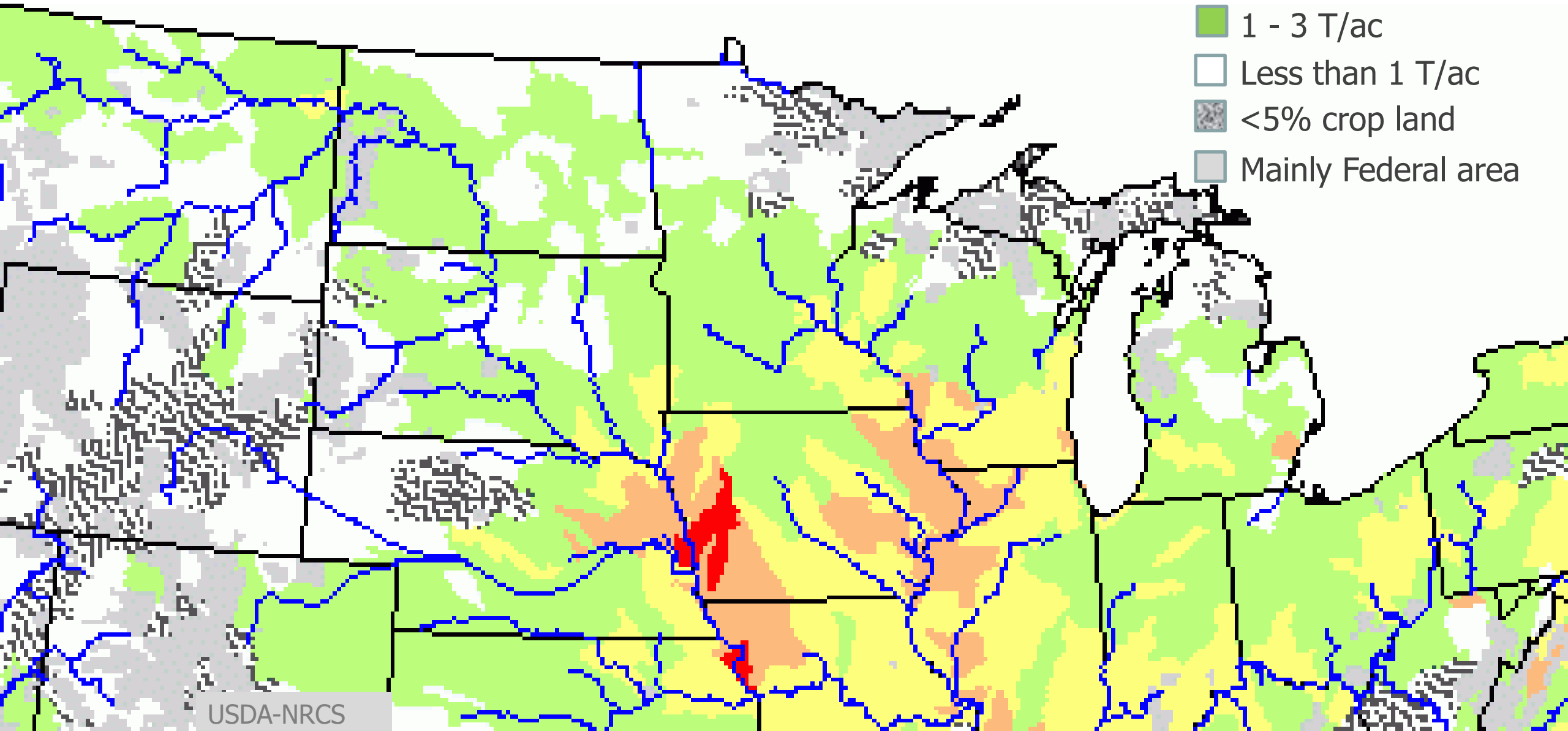
Adapted from Walther, University of Manitoba-2017

Strip till used 34% less fuel than vertical till at 6°

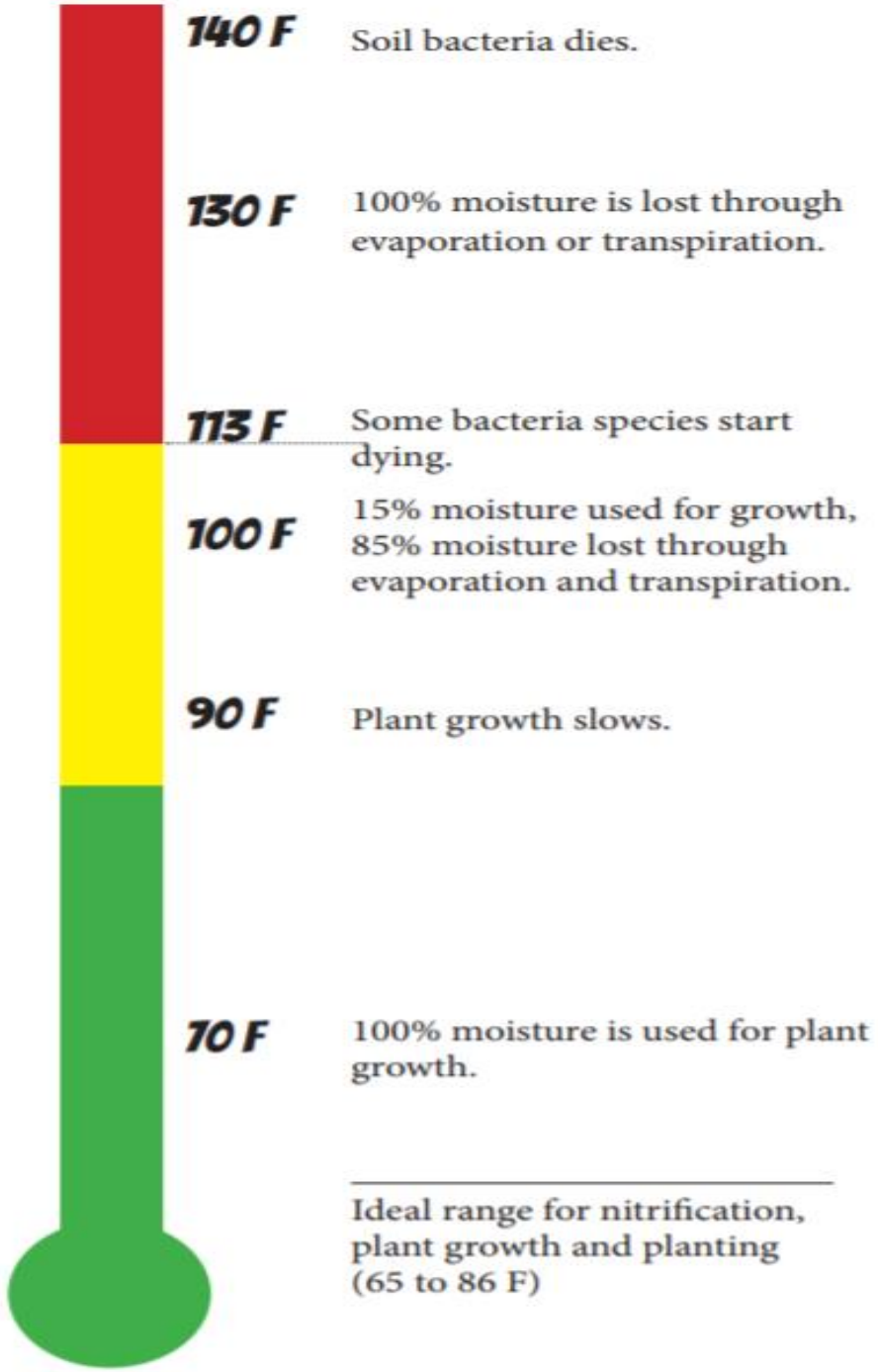


Adapted from Walther, University of Manitoba-2017

Average Annual Water Erosion



ISU


140 F
Soil bacteria dies.
130 F
100% moisture is lost through evaporation or transpiration.
113 F
Some bacteria species start dying.
100 F
15% moisture used for growth, 85% moisture lost through evaporation and transpiration.
90 F
Plant growth slows.
70 F
100% moisture is used for plant growth.
Ideal range for nitrification, plant growth and planting (65 to 86 F)

CROP RESIDUE PRODUCTION - MN

Crop	Crop Residue (lb/a)
Corn 160 bu/a	7,950*
Soybean 32 bu/a	1,900*
Wheat 58 bu/a	3,500*
Oats	1,600 – 2,400
Clover -cover crop	900 – 4,900
Oat/rye -cover crop	1,000 – 5,500

* Johnson, Allmaras, Reicosky – Western MN numbers

Carbon Content of Manure

Specie	Liq./Dry	Carbon
Dairy	Dry	35 #/T
	Liq.	39 #/1000 gal
Beef	Dry	30 #/T
Swine	Liq.	39 #/1000 gal
Poultry	Dry	34 #/T

1 large round bale = 1,200 lbs of residue
= 600 lbs of Carbon removed

Samples taken in 2004, AGVISE Analysis

Factors of Residue Removal

Grain Yield (bu/ac)	Corn Residue Yield	Cont. Corn MBP	Cont. Corn CP / NT	Corn-Soybean MBP	Corn-Soybean CP / NT
	---------- Bales that Could be Harvested*----------				
100	3.5	0	0	0	0
125	4.4	0	0.5	0	0
150	5.3	0	1.4	0	0
175	6.2	0.5	2.3	0	0
200	7.0	1.4	3.1	0	0.9

Cost of Nutrients Removed - Corn

	Nutrient	Dry Ton
Corn	N (16#)	$14.72
	P_2O_5 (5.8#)	$ 3.71
	K_2O (40#)	$17.20
	Sulfur (3#)	$ 0.99
Total	$36.62 (or $21.97 per 1,200# bale)	

N not available the next growing season

N = $0.92, P = $0.64, K = $0.43, S = $0.33

Source International Plant Nutrition Institute

COST OF NUTRIENTS REMOVED - SOYBEAN

	Nutrient	Dry Ton
Soybeans	N (40#)	$36.80
	P_2O_5 (8.8#)	$ 5.63
	K_2O (47#)	$15.91
	Sulfur (6.2#)	$ 2.05
Total	$60.39 ($36.23 per 1,200# bale)	

N not available the next growing season

N = $0.92, P = $0.64, K = $0.43, S = $0.33

Source International Plant Nutrition Institute

COST OF NUTRIENTS REMOVED - WHEAT

	Nutrient	Dry Ton
Wheat	N (14#)	$14.92
	P_2O_5 (3.3#)	$ 2.11
	K_2O (24#)	$10.32
	Sulfur (2.8#)	$ 0.92
Total	$28.27 ($16.96 per 1,200# bale)	

N not available the next growing season

N = $0.92, P = $0.64, K = $0.43, S = $0.33

Source International Plant Nutrition Institute

Even a Chisel Plow can be a Conservation Tool

Photo: Dick Wolkowski, UW

Chisel Plow Points

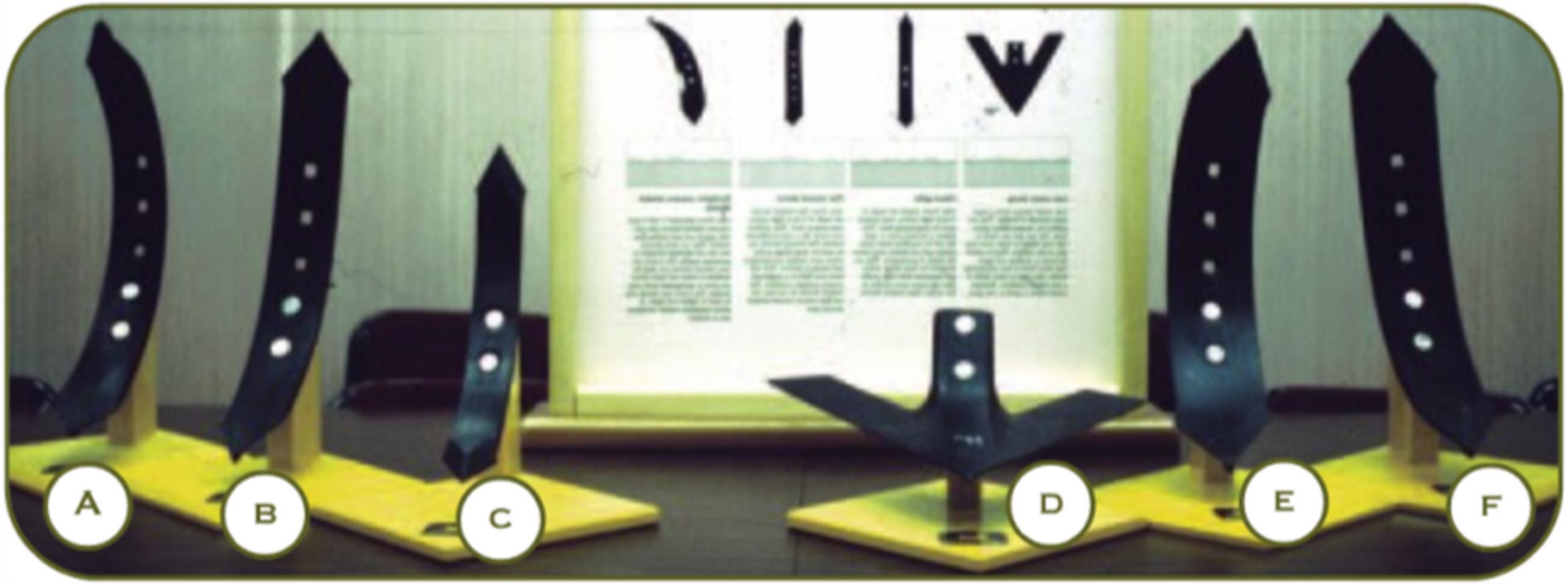


Photo: Dick Wolkowski, UW

Twisted Shovel vs. Sweep

Provided by Dick Wolkowski, UW)