



Is Compaction Squeezing Your Yields?

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Wheel tracks





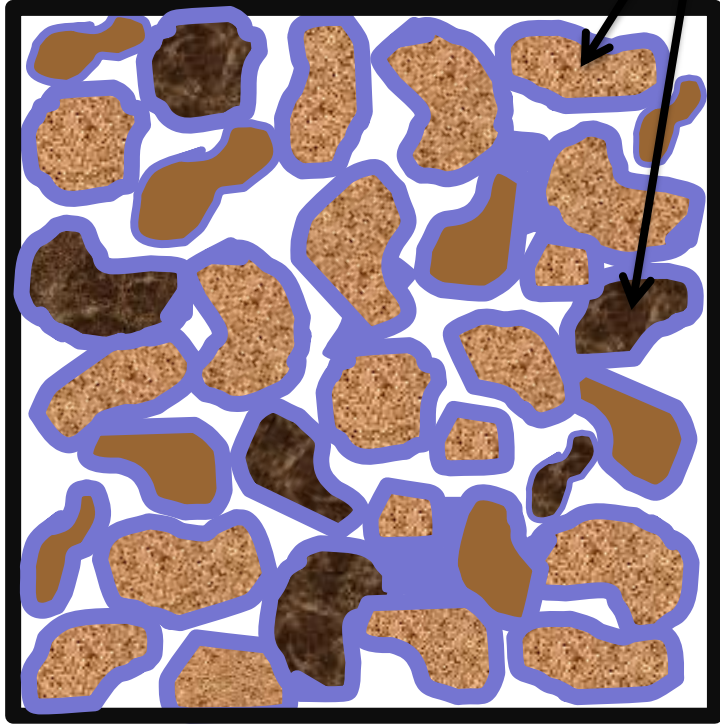






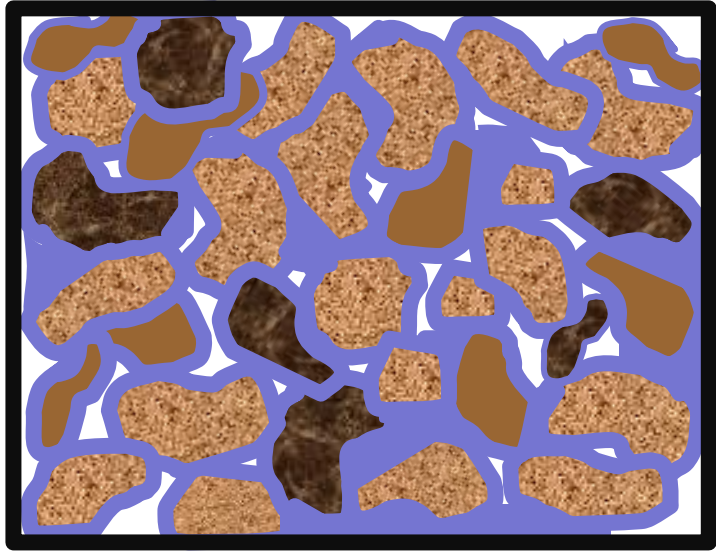
50% Air
50% Water

Sand, Silt, or Clay



Not Compacted

Air
Water



Compacted

Soil remains cooler and wetter

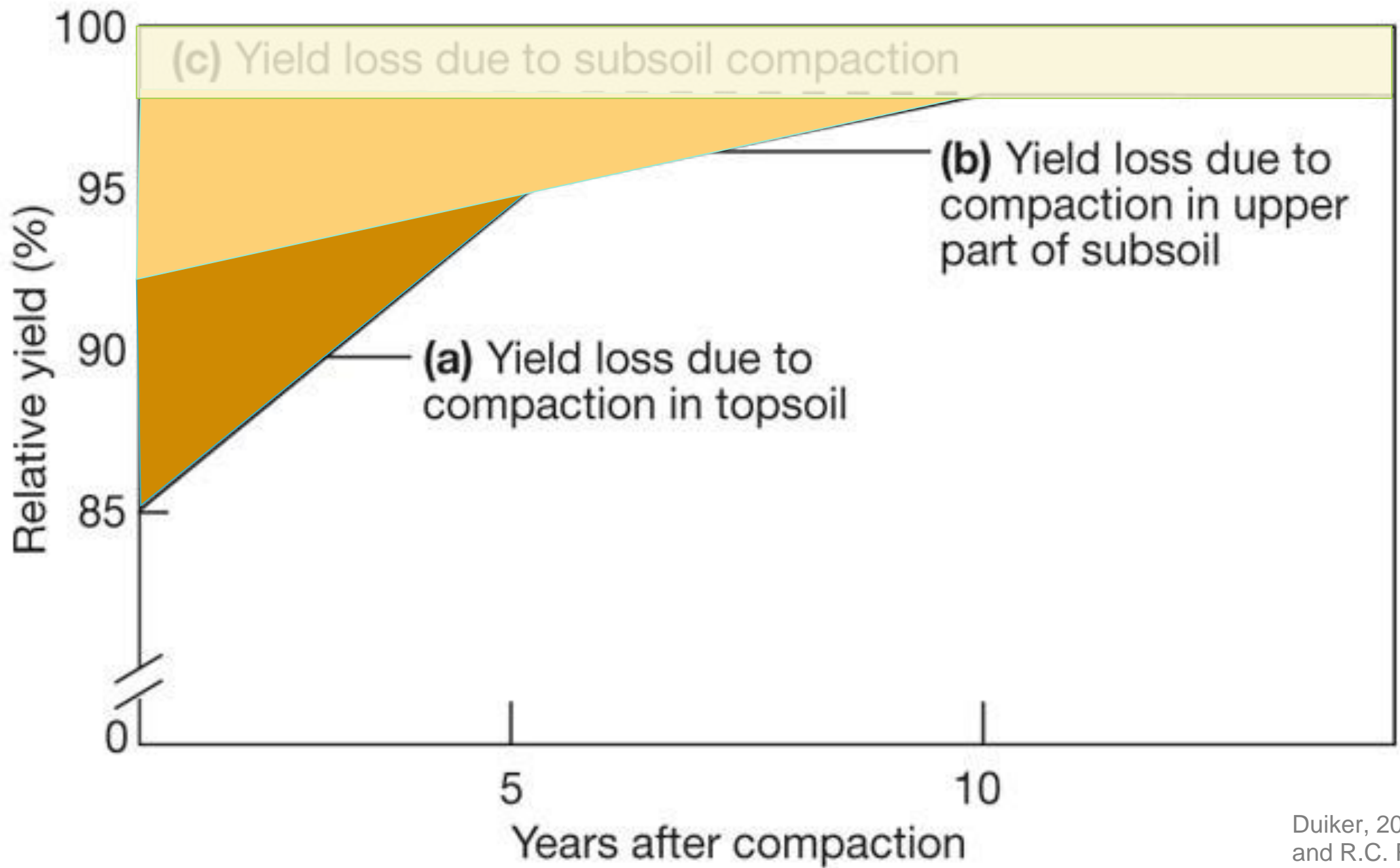
Is Structure Important?



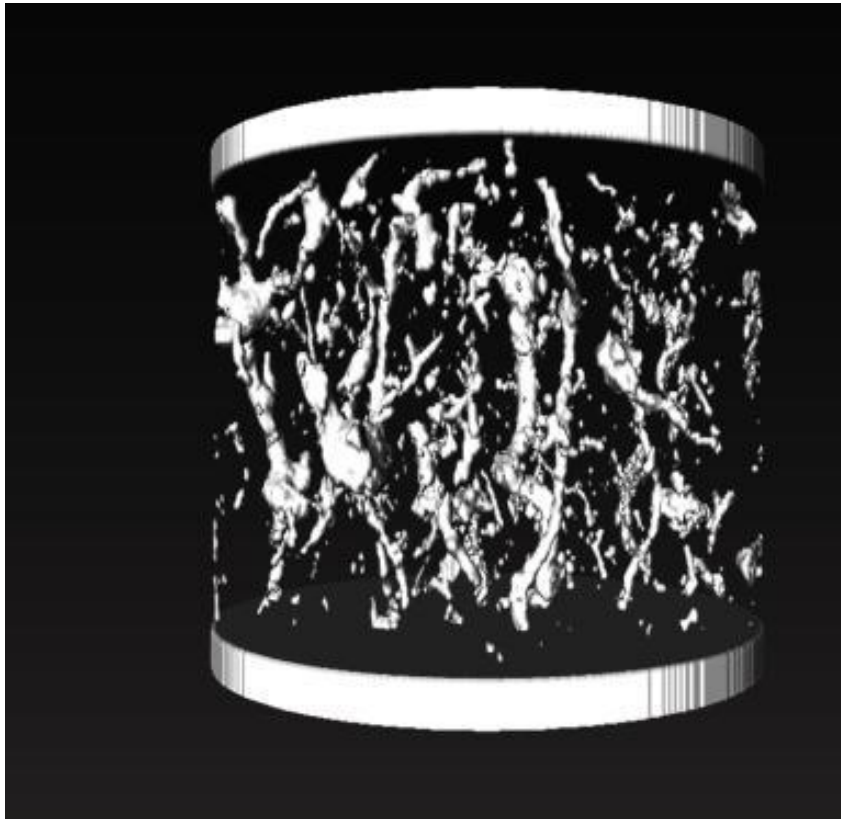
Longevity of Soil
Compaction?

Depends on depth





CT Image of a Clay Affected by Compaction 27 Years Previous



Compaction Effect on Yield

up to 60%

Typically 15-30% in our region

Factors Affecting Compaction

Soil moisture

Axle loads

Ground pressure (PSI)

Traffic passes

Aggregation (soil health)



1

Working soil when it's too wet

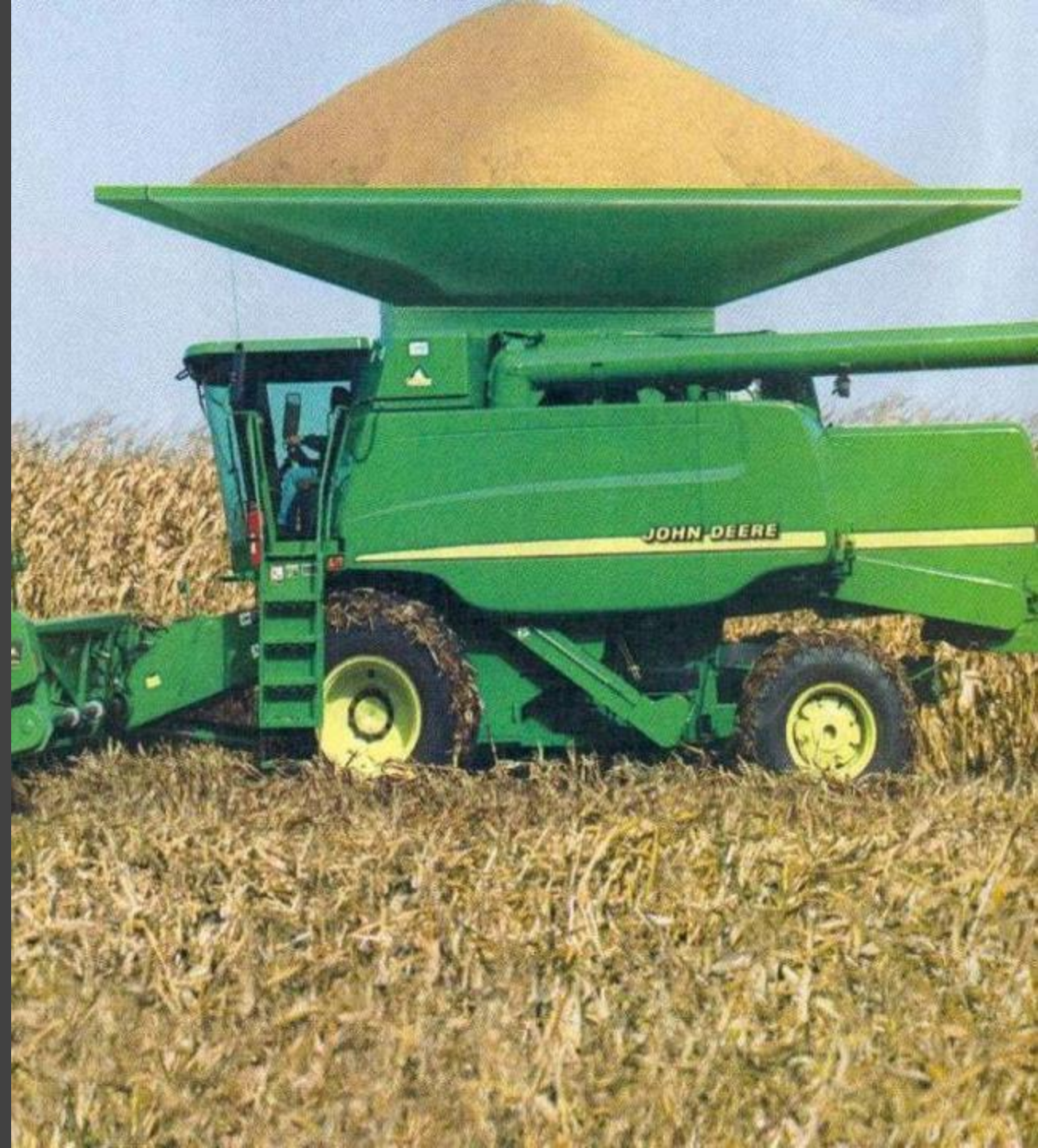


Soil Moisture

- Water acts as a lubricant
- Greatest compaction occurs at moistures near field capacity (22% water content)

2

Heavy Axle Loads



Equipment (full weight)	Axle Load (Tons/axle)
Gravity wagon, 385 bu, 2 axles	6-7
Gravity wagon, 560 bu, 2 axles	10
Terra-gator, rear axle	12-18
Grain cart, 720 bu, 1 axle	22
Grain cart, 1,200 bu, 1 axle	35-40
Grain cart, 2,000 bu, 1 axle	70-76

Stay Around
5 to 10 tons
per Axle

Equipment (full weight)	Axle Load (Tons/axle)
4,200 gal slurry tank, 2 axles	10-12
8,500 gal slurry tank, 3 axles	15
8,500 gal slurry tank, 4 axles	11

Stay Around
5 to 10 tons
per Axle

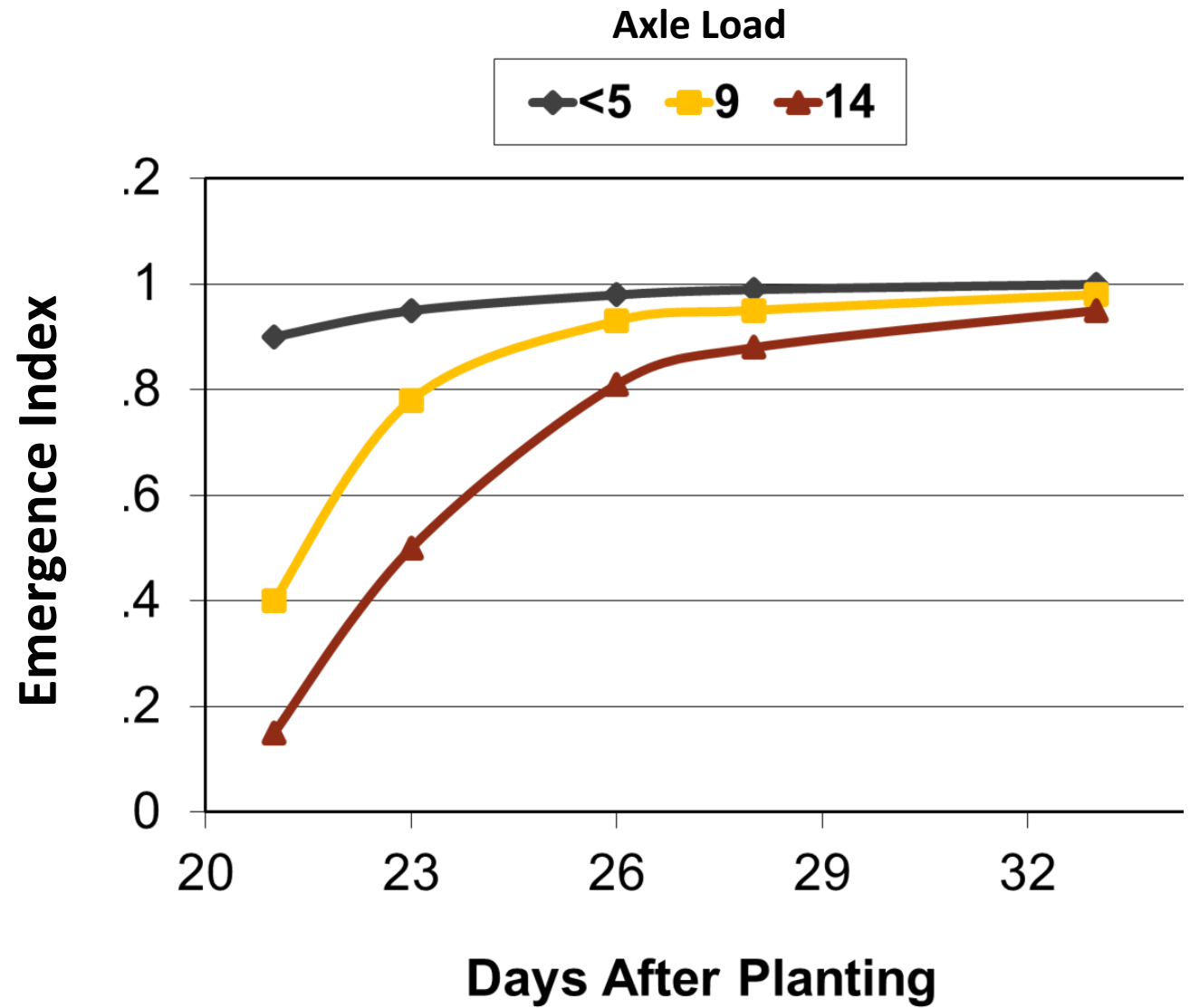
Depth of Compaction

Weight (tons/axle)	Depth (inches)
4.4	12"
6.5	16"
11	20"
16.5	24"

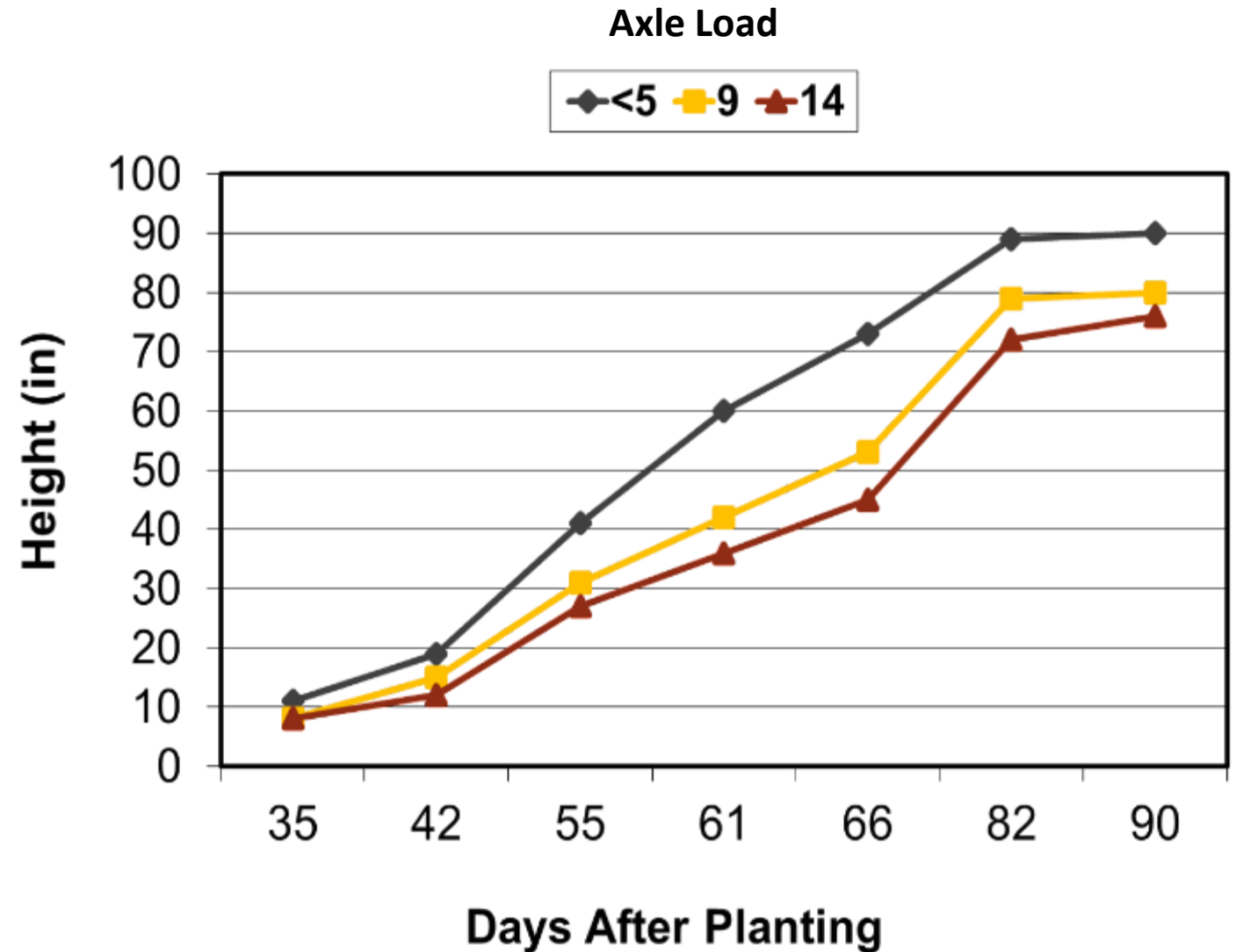
Hakaansson and Reeder, 1994



Corn Emergence vs Axle Load



Corn Height vs Axle Load



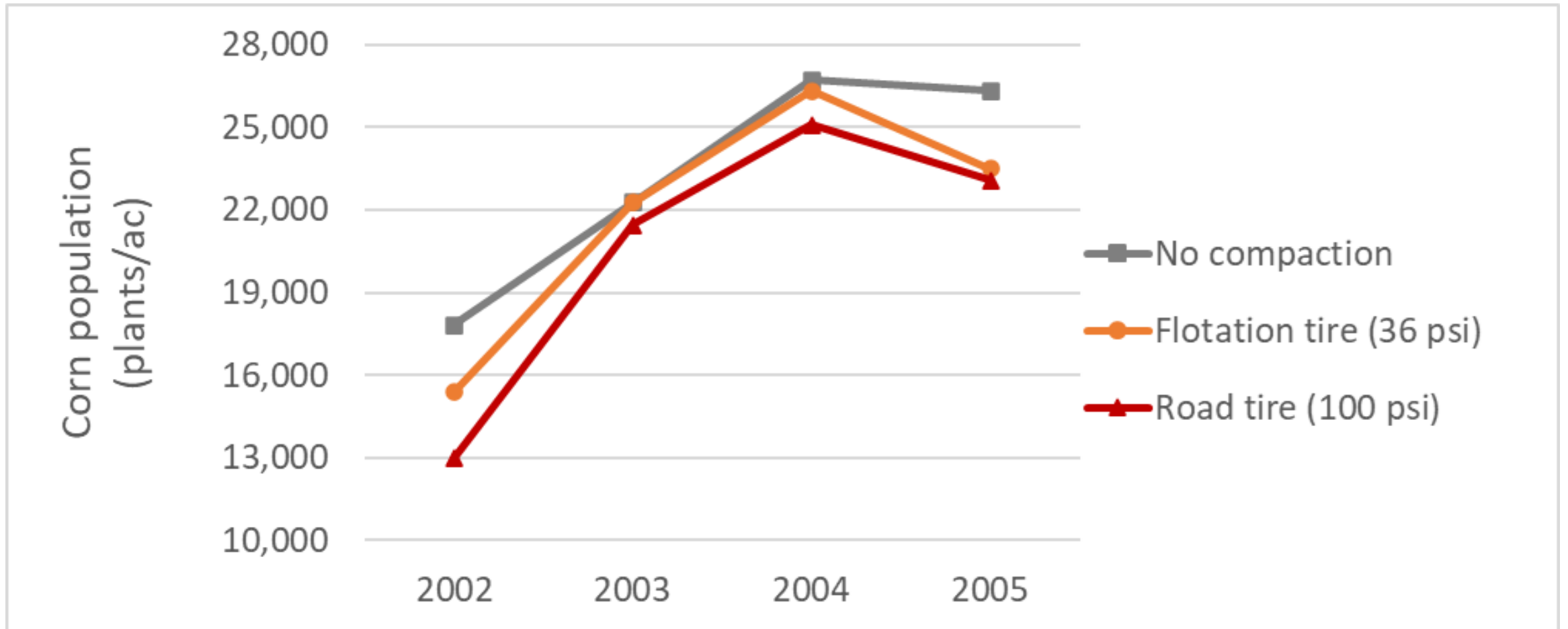
3

Over-Inflated Tires and Ground Pressure

- Tractors, tanks, trucks, ...
- Bigger tires = lower pressures
- Ideally 10 psi



Corn Population vs Tire Pressure



Tire Size	(psi)
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20 x 20 (2 axles)	32.3
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28.1 x 26 (2 axles)	16.5
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Example:

Slurry 6,000-gal Tank

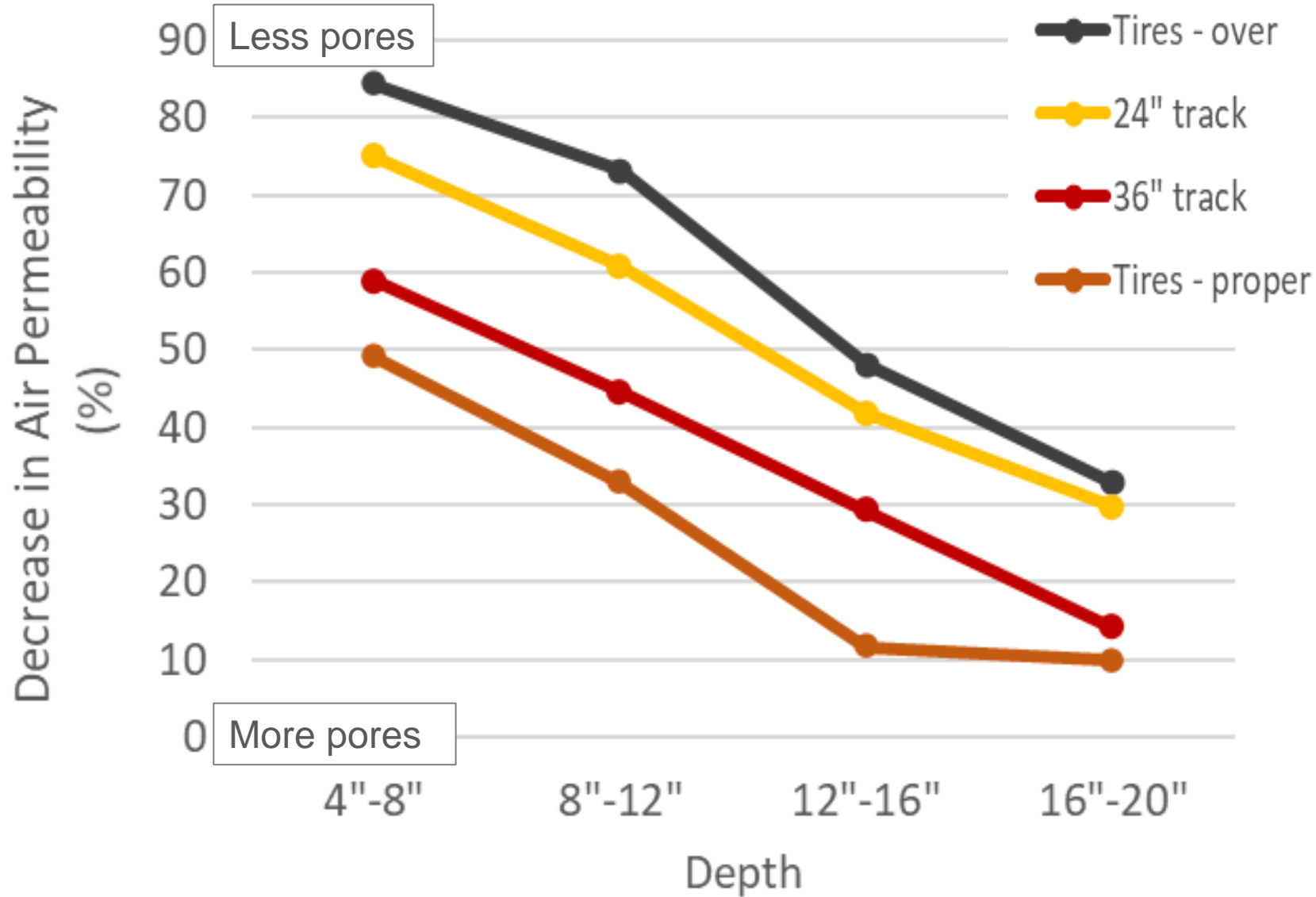
Approx. 55,000 lbs. (full)



Tractor Performance

Tire Pressure	Fuel Use	Area Worked	Tractor Speed	Wheel Slip
psi	gal/ac	ac/hour	mph	%
13/11 – properly inflated	1.43	13.2	6.0	7.1
24 – over inflated	1.75	12.2	5.6	10.8

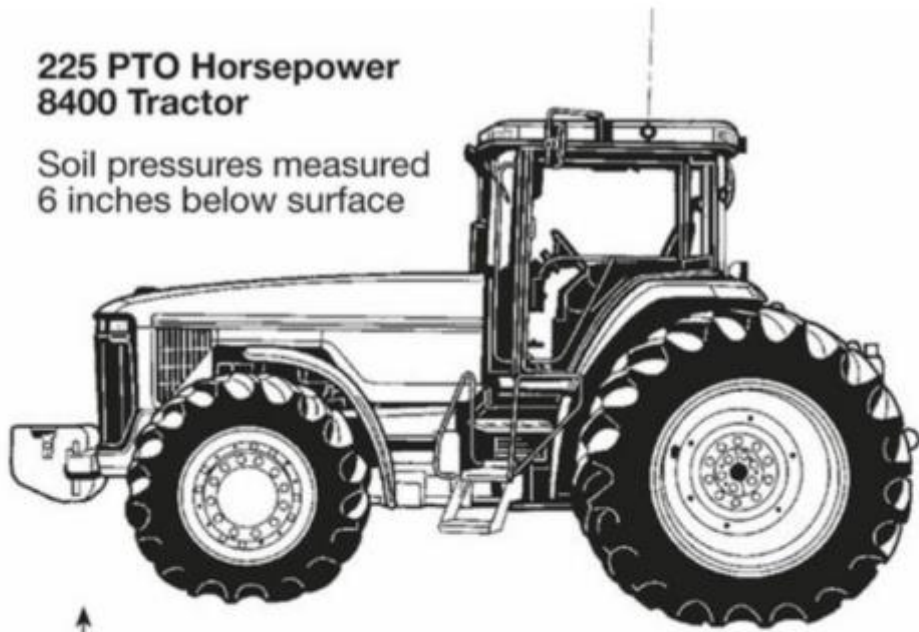
OSU Study



- JD 8870 4WD with 710/70R38 at 6 and 24 psi
- Cat Challenger with 2' and 3' tracks
- Towing had similar results
- 4 reps

**225 PTO Horsepower
8400 Tractor**

Soil pressures measured
6 inches below surface



Front Tires

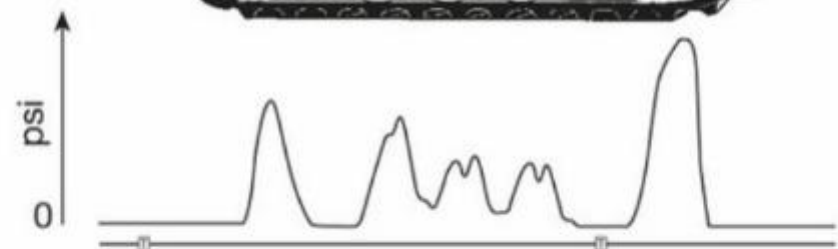
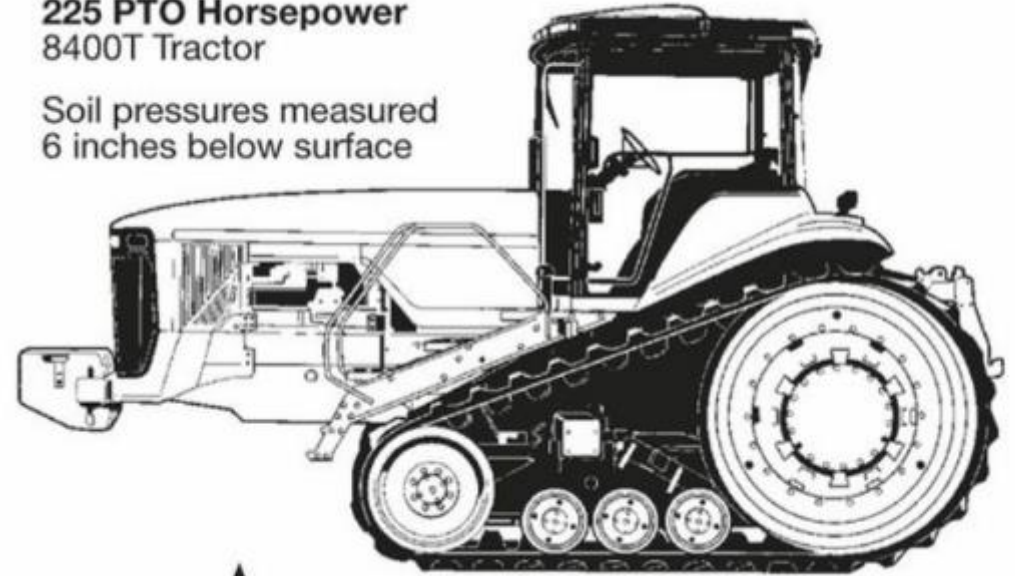
16.9-30
Inflation pressure: 21 psi
Balasted weight: 25,000 pounds

Rear Tires

18.4R-46 Duals
Inflation pressure: 10 psi

**225 PTO Horsepower
8400T Tractor**

Soil pressures measured
6 inches below surface



Track Width

16 inches
Inflation pressure: NA
Balasted weight: 25,300 pounds

Average contact pressure under rubber tracks is low, however, there are pressure points under guide wheels



Ground Pressure Factors for Tracks

Average psi changes with:

- positioning of mid-wheel rollers
- spring stiffness at attachment points
- track stiffness
- track width vs carriage width
- dynamic weight transfer when under drawbar load



4

Unchecked
Traffic
Patterns

One vs Multiple Passes

Up to 80% of the
compaction happens
on the first pass





5

Lack of Soil
Structure


#1 Natural Defense Against Soil Compaction

And tillage destroys
structure and
macropores





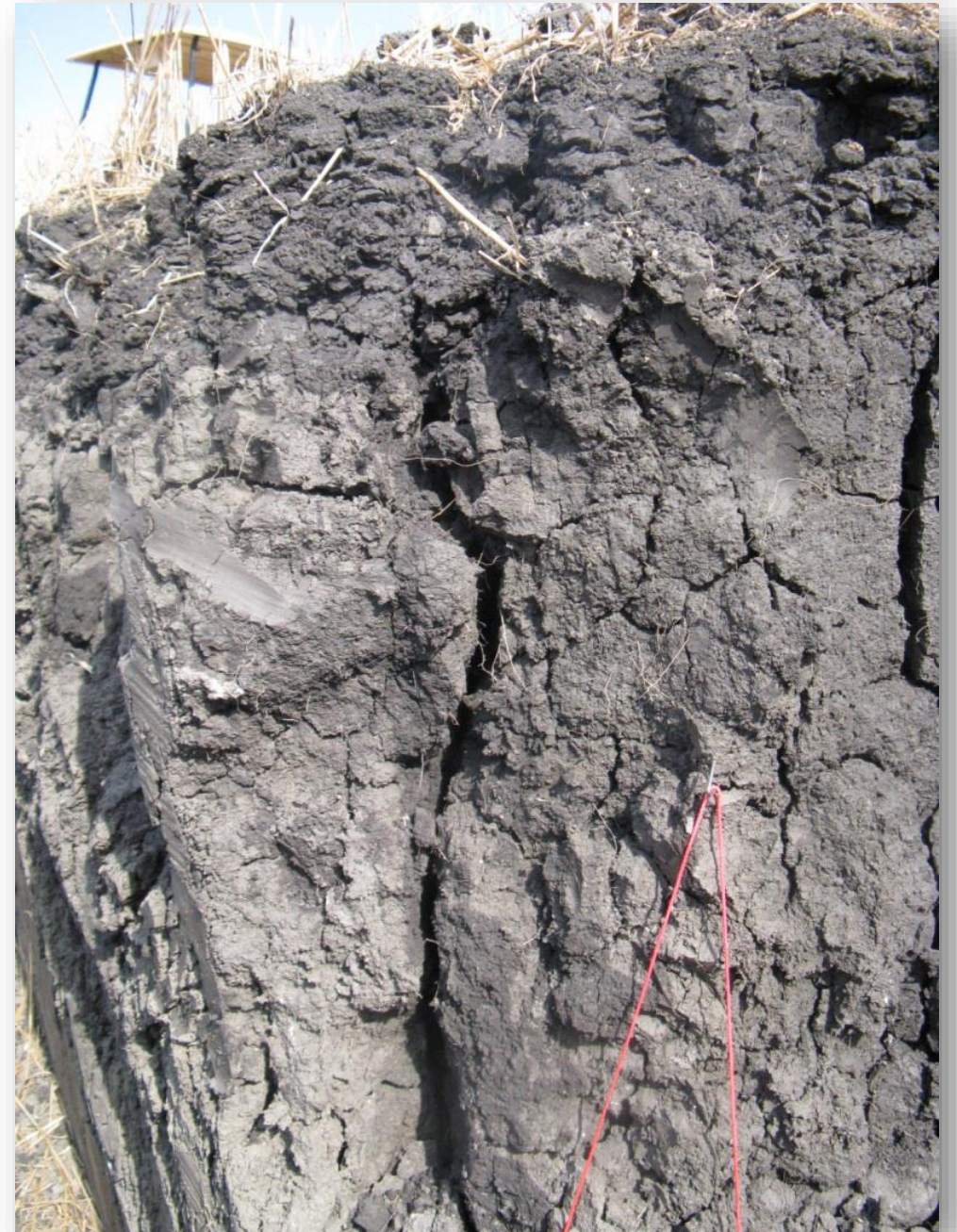
- Macropores are less than **1%** of all soil pores
- But they contribute **up to 70%** of the water infiltration



How to Alleviate Soil Compaction



In dry years, there is
“natural tillage”



—

Biologically Alleviating Soil Compaction



Cover Crops

- Create pore spaces for infiltration and root growth
- Stabilize aggregates
- Break through plow pans
- Cover crops need time to change the soil
- Use spring moisture



Cover Crops and Plow Pans

- 3 cycles of a 2-year rotation
- Plow pan at 4-6"



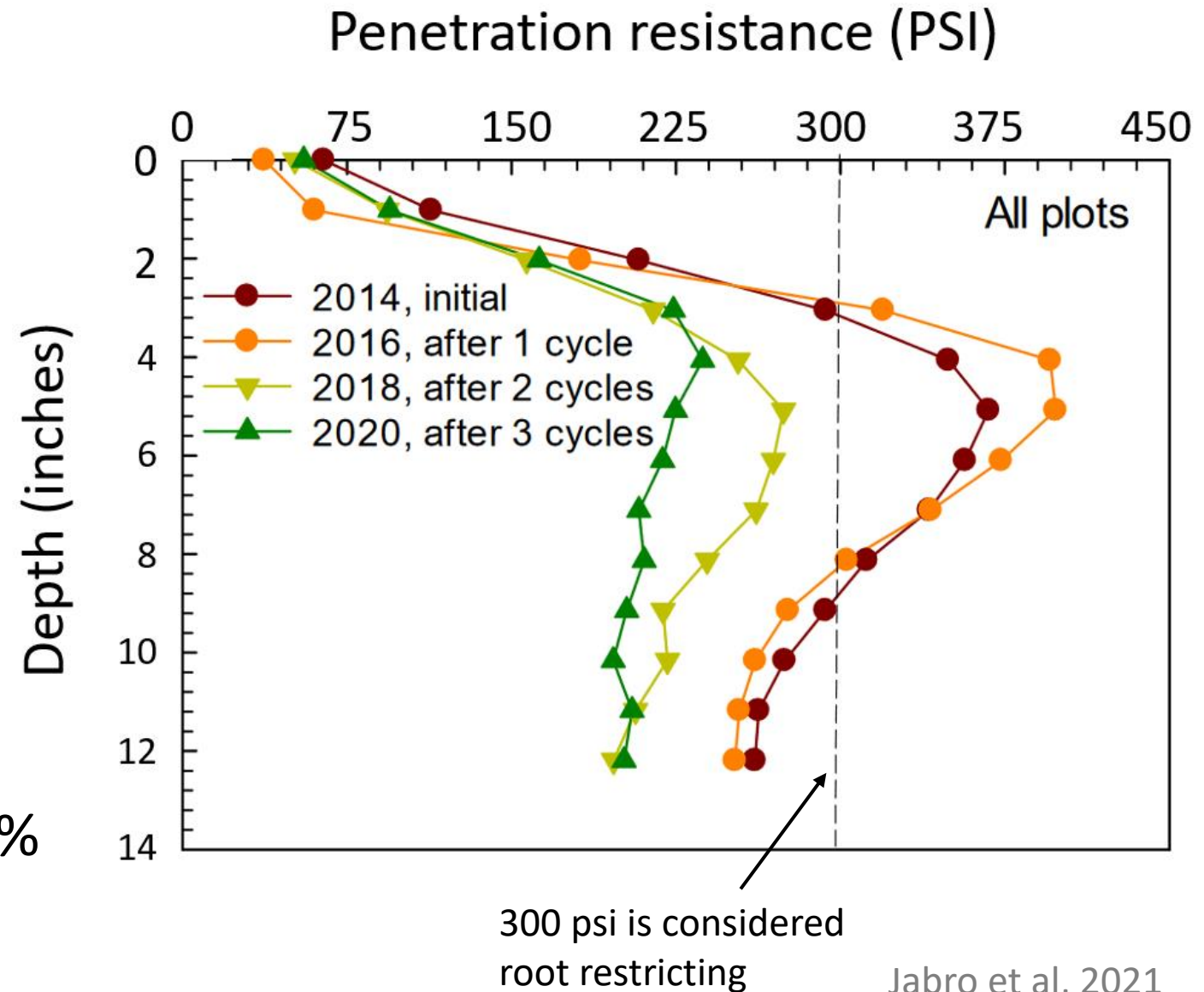
Cover Crops and Plow Pans

After 2 cycles (4 yrs)

- bd in plow pan ↓ 25%

After 3 cycles (6 yrs)

- bd in plow pan ↓ again by 32%



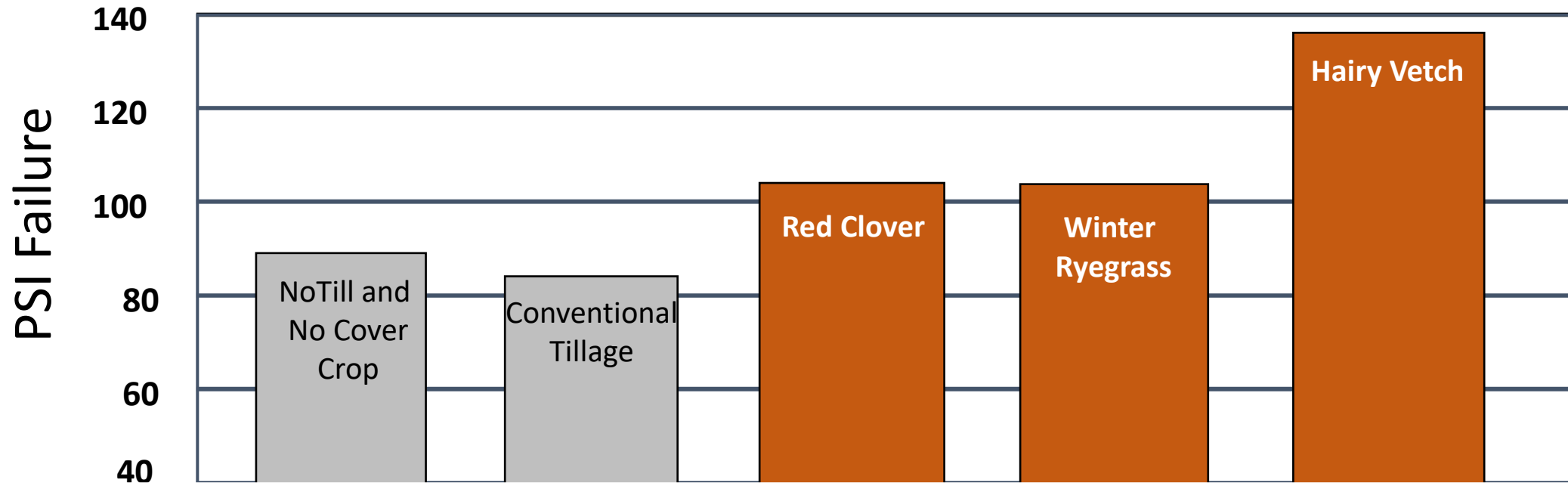
Soil Strength and Trafficability

A measure of the capacity of a soil to withstand stresses without giving way to those stresses by collapsing or becoming deformed.



Cover Crops Improve Trafficability

Due to either reduced moisture and/or better structure





Mechanically Alleviating Soil Compaction



Find the
compacted
layer





Or dig a pit



Set shanks
1-2 inches below
compacted layer

Use most
non-invasive,
straight shank



Photos by Dick Wolkowski, UW



- Work soil when dry
- Rip only where needed (precision tillage)



- Do not drive on ripped soil again
- Use controlled traffic practices



Compaction Summary

- Heavy loads move soil compaction deeper
- Higher ground/tire pressures increase the intensity of the compaction

UPPER MIDWEST TILLAGE GUIDE

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Cailey Gasch (North Dakota State University) and Jodi DeJong-Hughes (University of Minnesota Extension)

Soil Organic Matter Does Matter

What is soil organic matter?

We hear all the time that organic matter is one of the most important components of soil. But what is it, exactly? One textbook definition is: **The organic fraction of the soil that includes plant, animal, and microbial residues in various stages of decomposition, biomass of soil microorganisms, and substances produced by plant roots and other soil organisms** (Weil & Brady, 2017). Basically, it is the material in soil that is derived from living organisms—whether it is a carcass, waste product, or other substance released from living organisms. Even though microbial cells are alive, they experience rapid population turnover - much like dead residues - and are often included in the definition of soil organic matter.

Soil organic matter or soil organic carbon?

Sometimes the terms **soil organic matter** and **soil organic carbon** are used interchangeably. That is because carbon makes up the majority of organic matter mass. Researchers estimate that carbon makes up about 58% of soil organic matter (Howard & Howard, 1990). Hydrogen, oxygen, nitrogen, phosphorous, and other nutrients make up the remaining mass. If you see a report that lists soil organic carbon (scientists often do this), you can convert it to organic matter by multiplying by 1.7.

Soil organic matter levels

The soil organic matter level in most mineral soils ranges from trace amounts up to 20%. If a soil has 20% or more organic material to a depth of 16 inches, then that soil is considered organic, and is termed a peat or muck depending on the extent of decomposition. These soils are taxonomically described as a Histosol (Fig. 1).

Histosols make up only about 1% of soils worldwide (Buol et al., 2003), and most soils have a much lower content of soil organic matter. Soils in the Northern Great Plains of the



Figure 1. A Histosol soil (Photo: Backheim and Hartmann, 2017).



Figure 2. Soil organic matter content across the United States (Image: Hargrove and Linnert, 1988)

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z.umn.edu/TillageGuide

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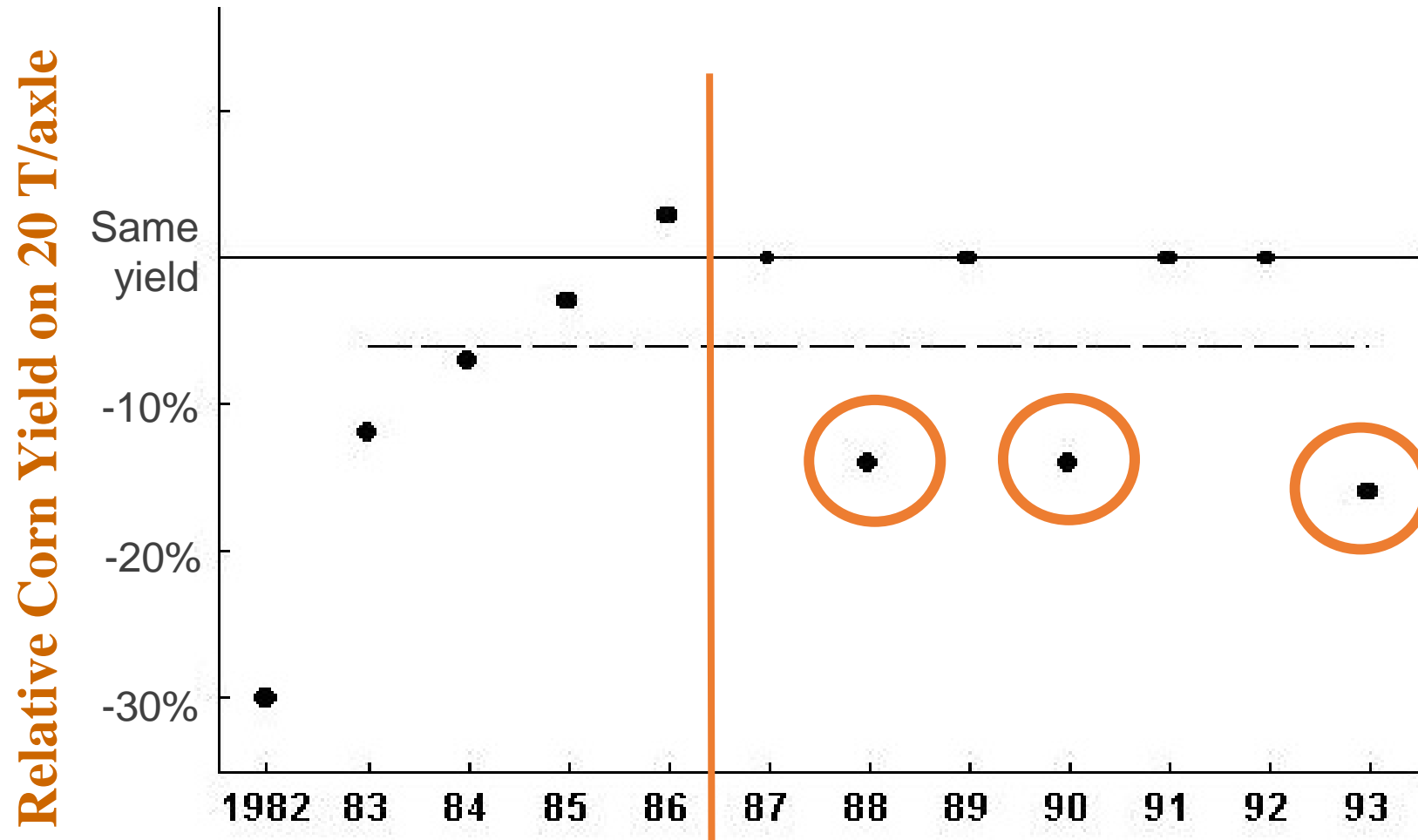
Aggregated versus Non-aggregated

- Better water infiltration
- More moisture stored for later
- Carrying capacity
- Better root growth
- Less erosion



Relative Corn Yield, Waseca, MN

(1 time application of 20T/axle)



Extensive Wheel Traffic



Yield reduced 24%

Wheel Traffic	45
No Traffic	59

-14 bu/ac

~80% of compaction happens on the 1st pass!

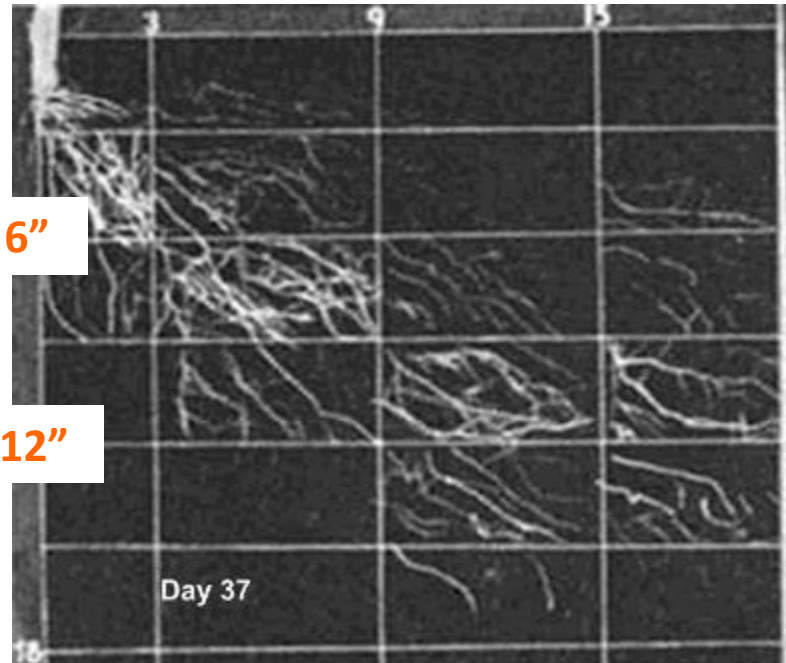


Nutrient Deficiencies

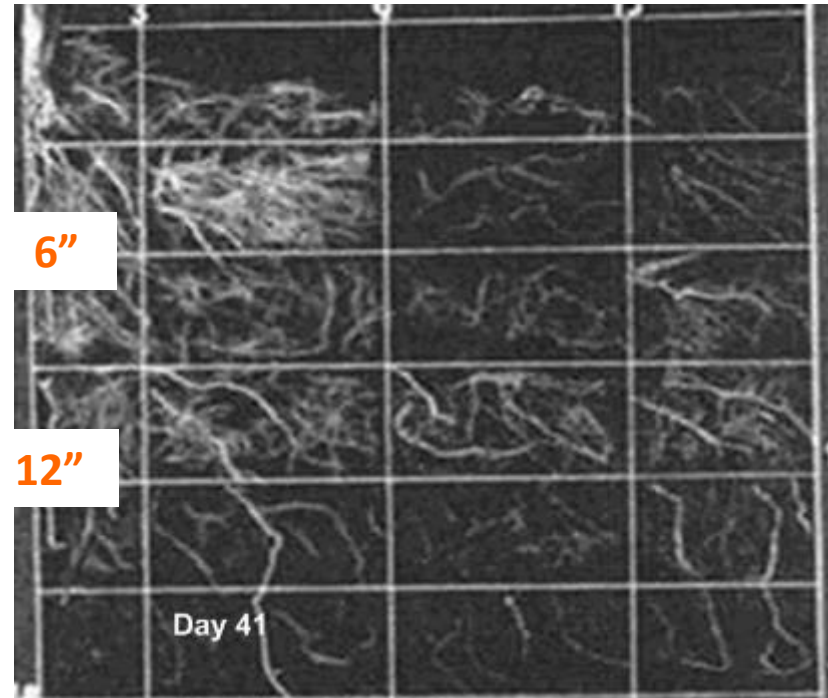
(esp. nitrogen and
potassium)

Corn Root Growth

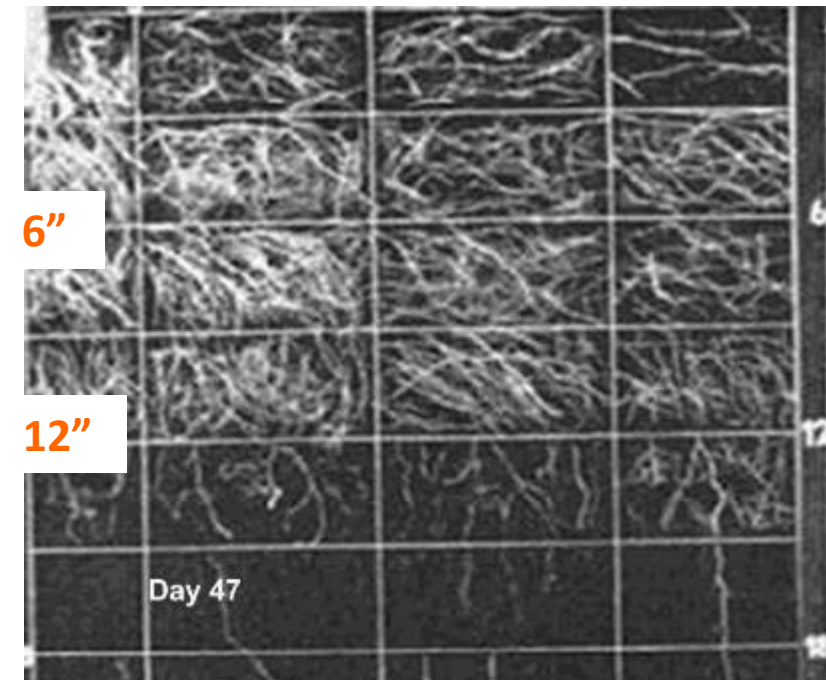
Day 37



Day 41



Day 47



Corn Root Growth with Wheel Traffic

Day 47

