UNIVERSITY OF MINNESOTA EXTENSION

Is Compaction Squeezing Your Yields?

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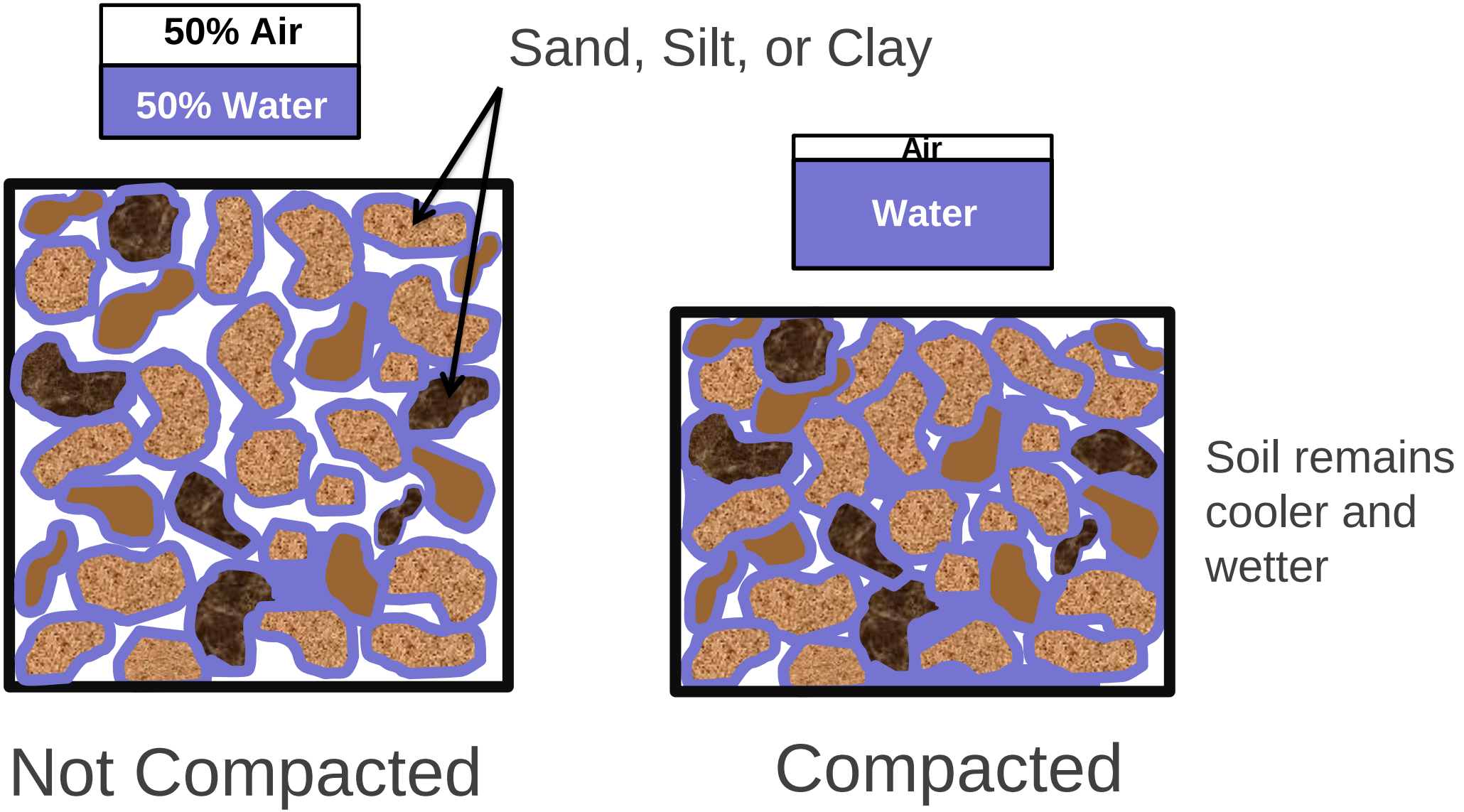
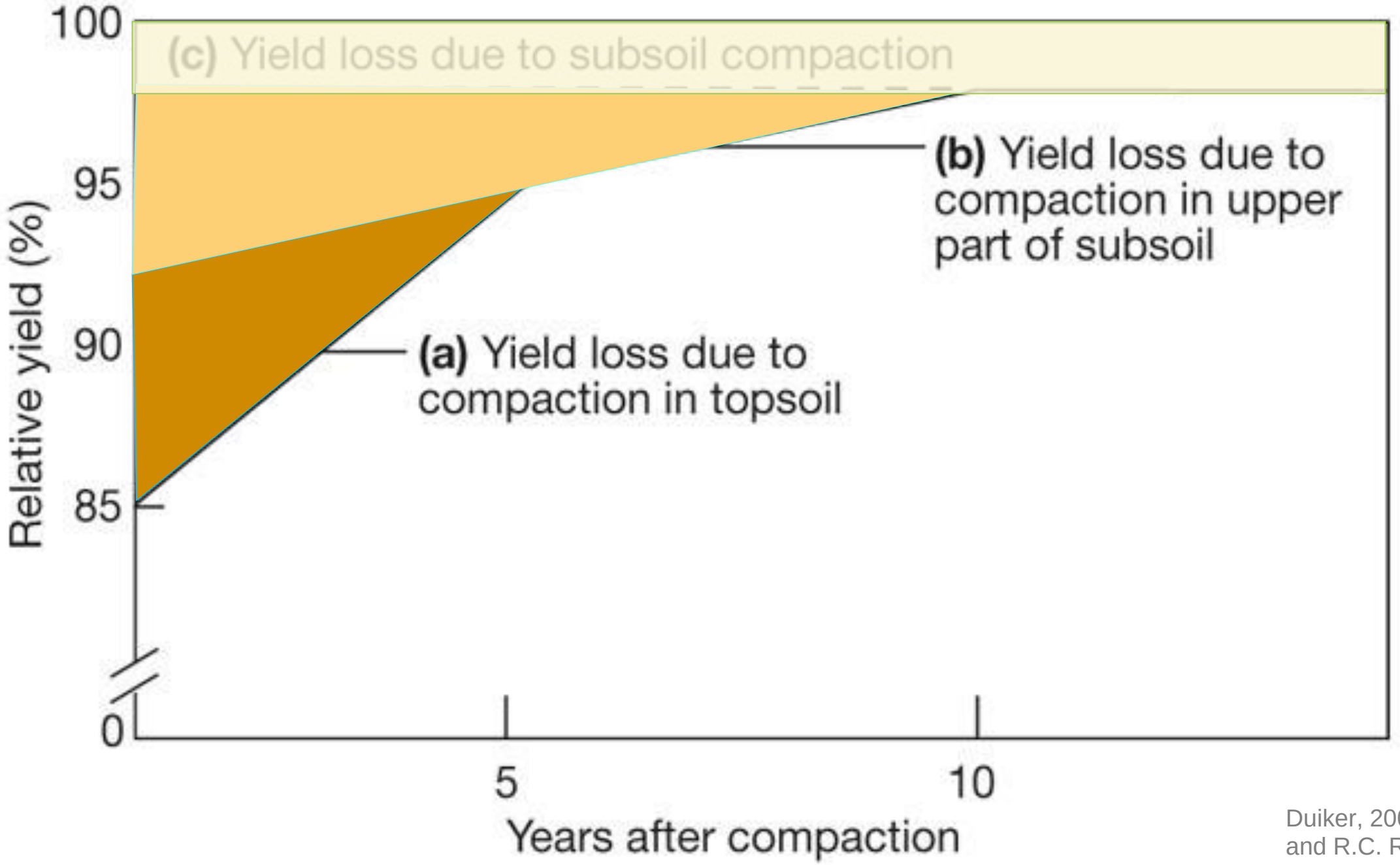
Wheel tracks


50% Air
50% Water
Sand, Silt, or Clay
Air
Water
Soil remains cooler and wetter
Not Compacted
Compacted

Is Structure Important?

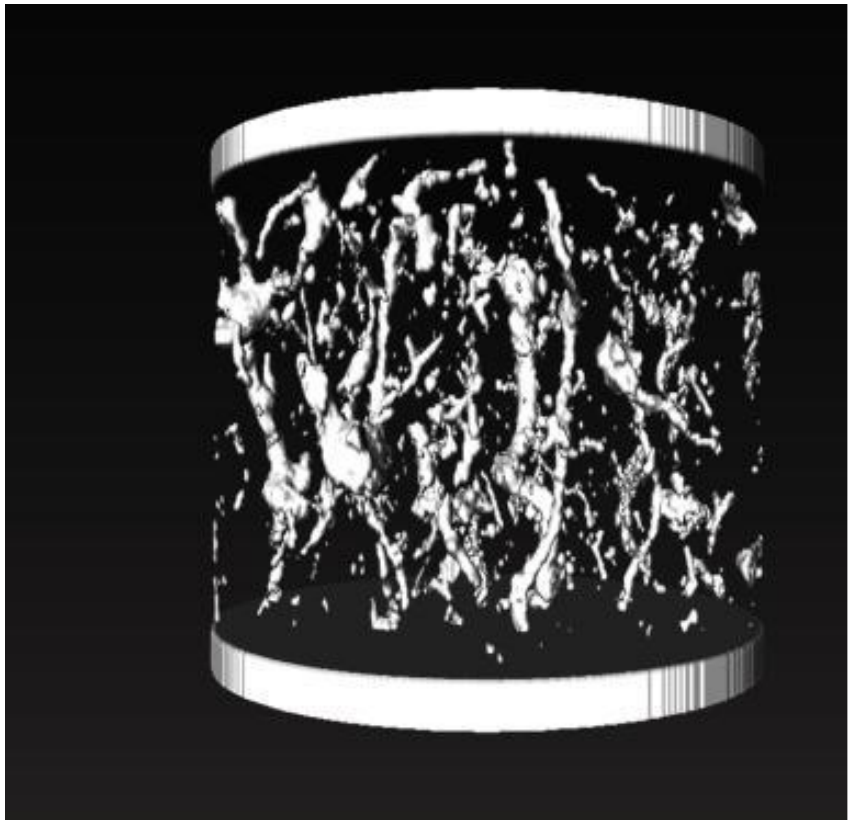
Longevity of Soil Compaction?

Depends on depth



Duiker, 2004; Hakansson, and R.C. Reeder. 1994

CT Image of a Clay Affected by Compaction 27 Years Previous



Schjonning et al, 2013

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)

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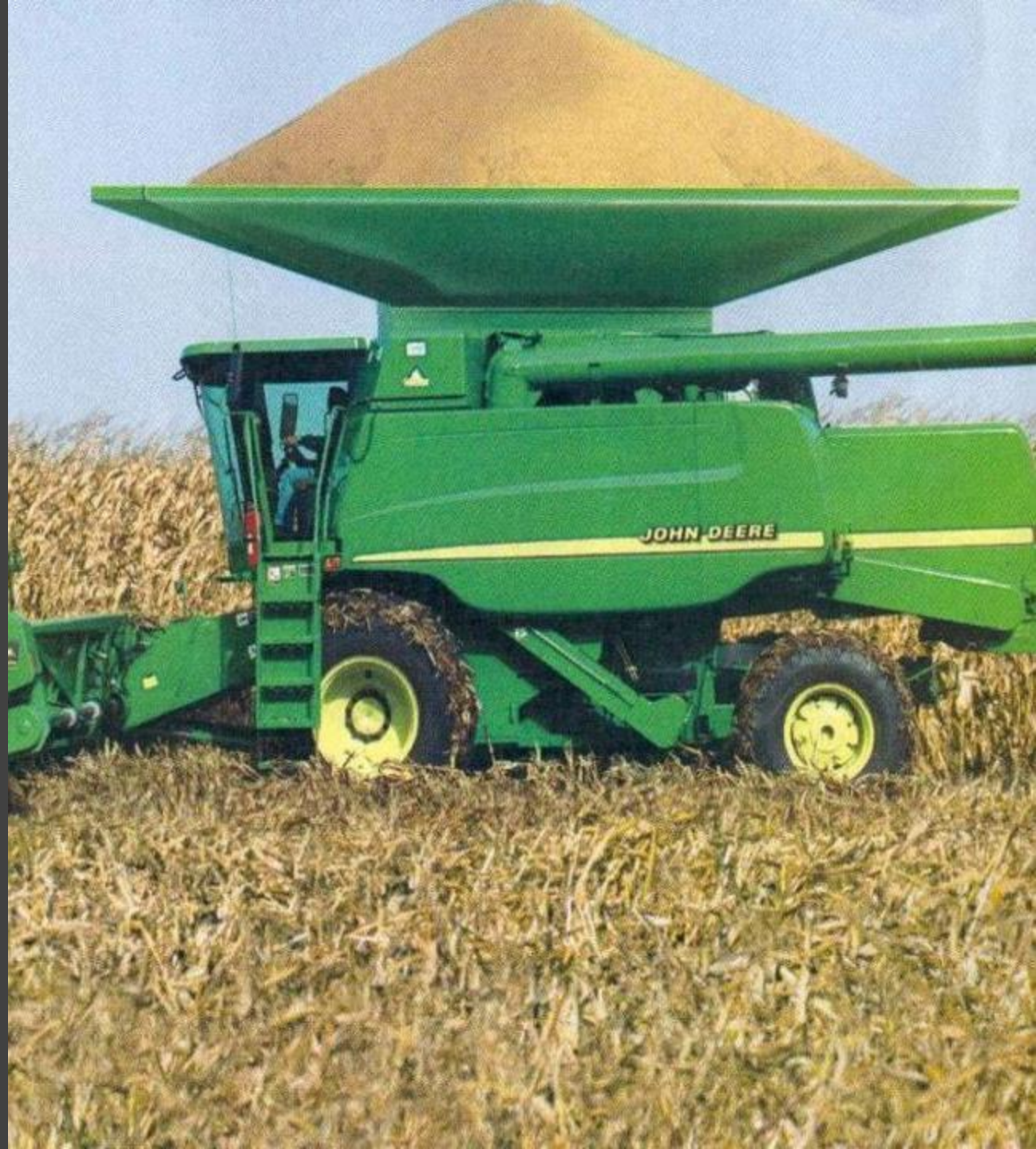
Heavy Axle Loads



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

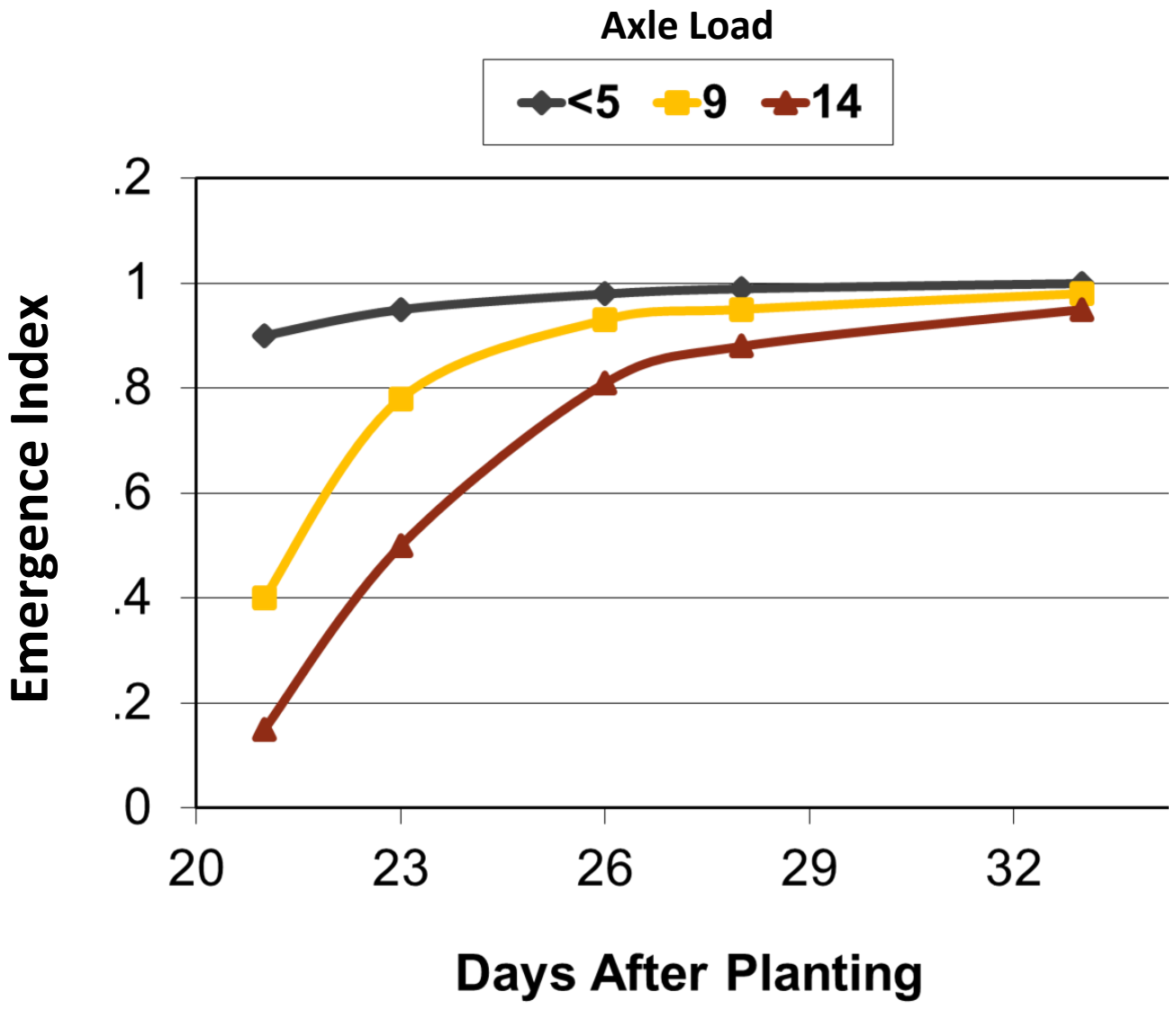
Stay Around 5 to 10 tons per Axle

Depth of Compaction

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

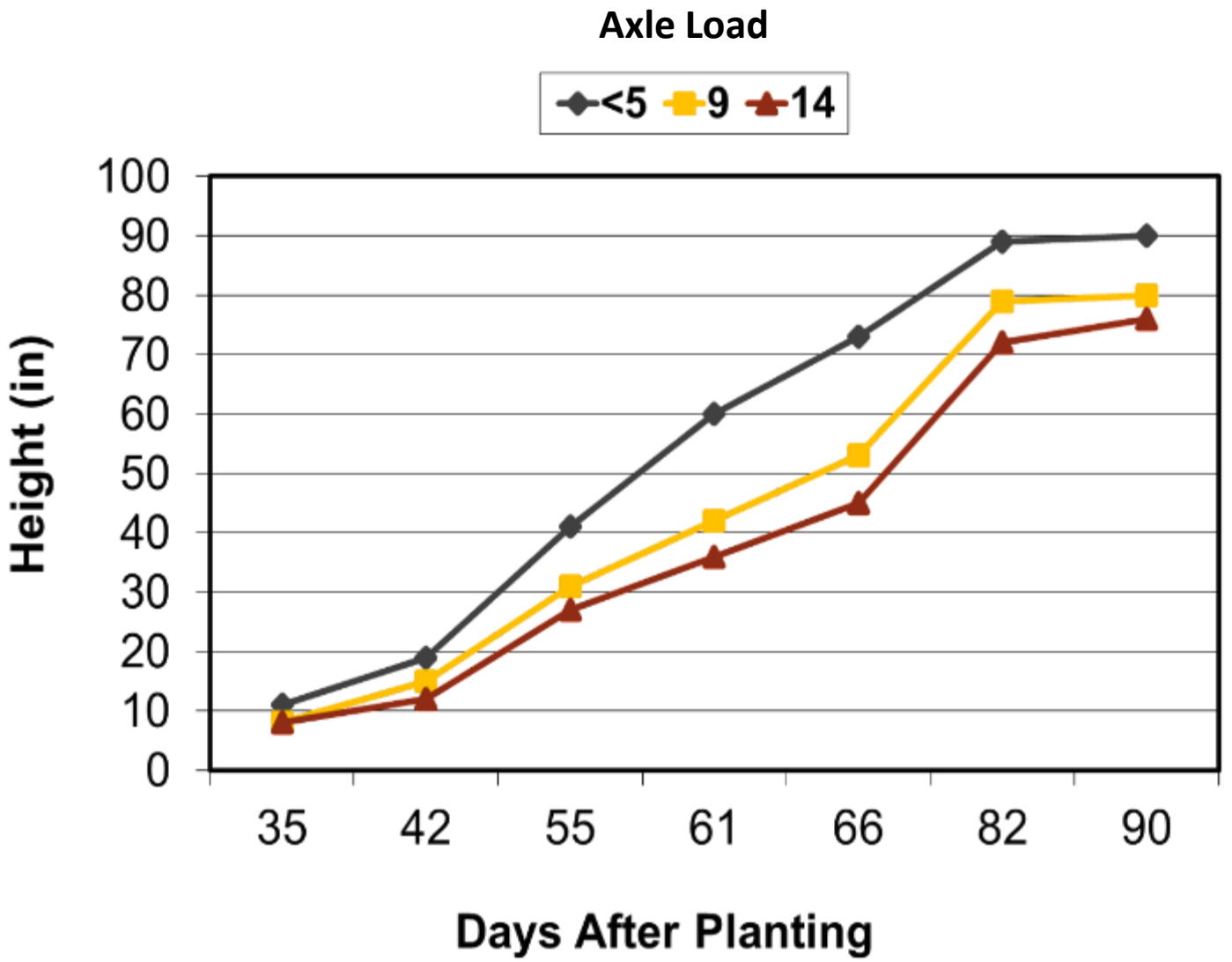
Hakaansson and Reeder, 1994

Corn Emergence vs Axle Load



Wolkowski and Lowery, UW, 2008

Corn Height vs Axle Load



Wolkowski and Lowery, UW, 2008

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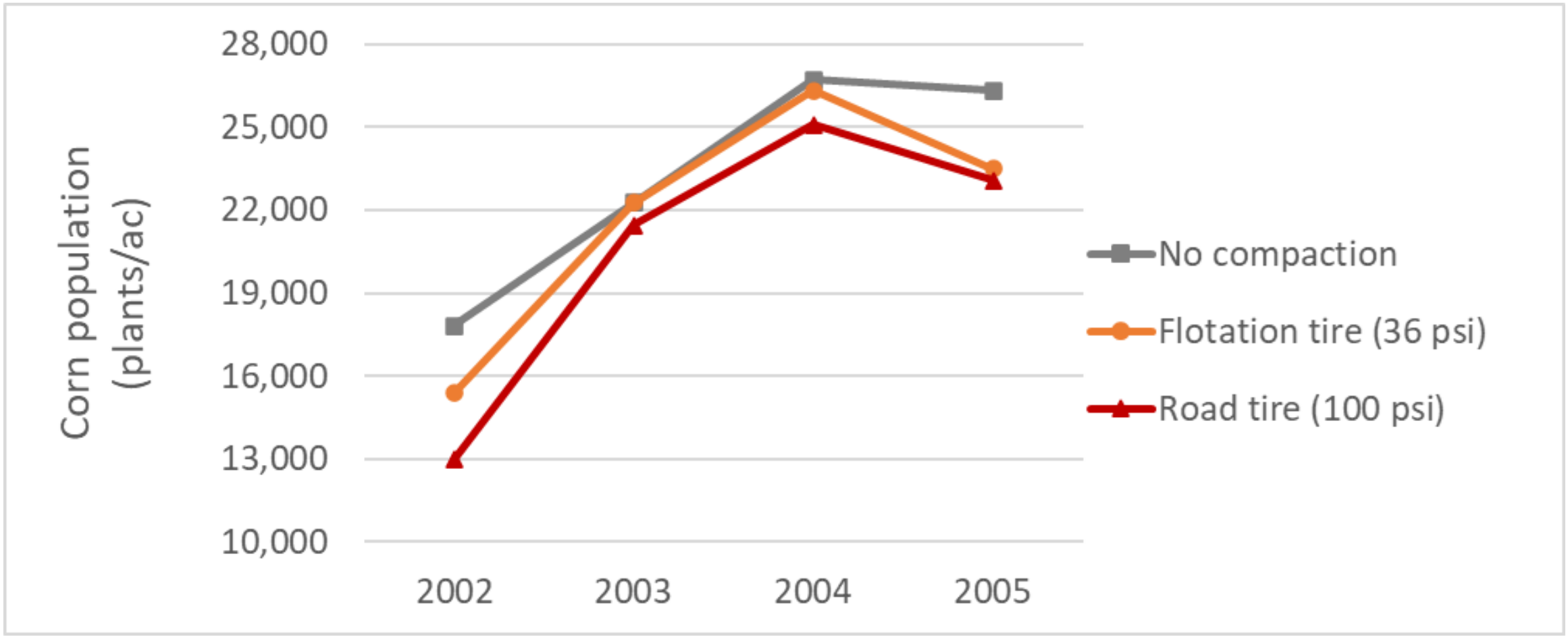
Over-Inflated Tires and Ground Pressure

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

Corn Population vs Tire Pressure



Krmenec, 2000

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

Example:

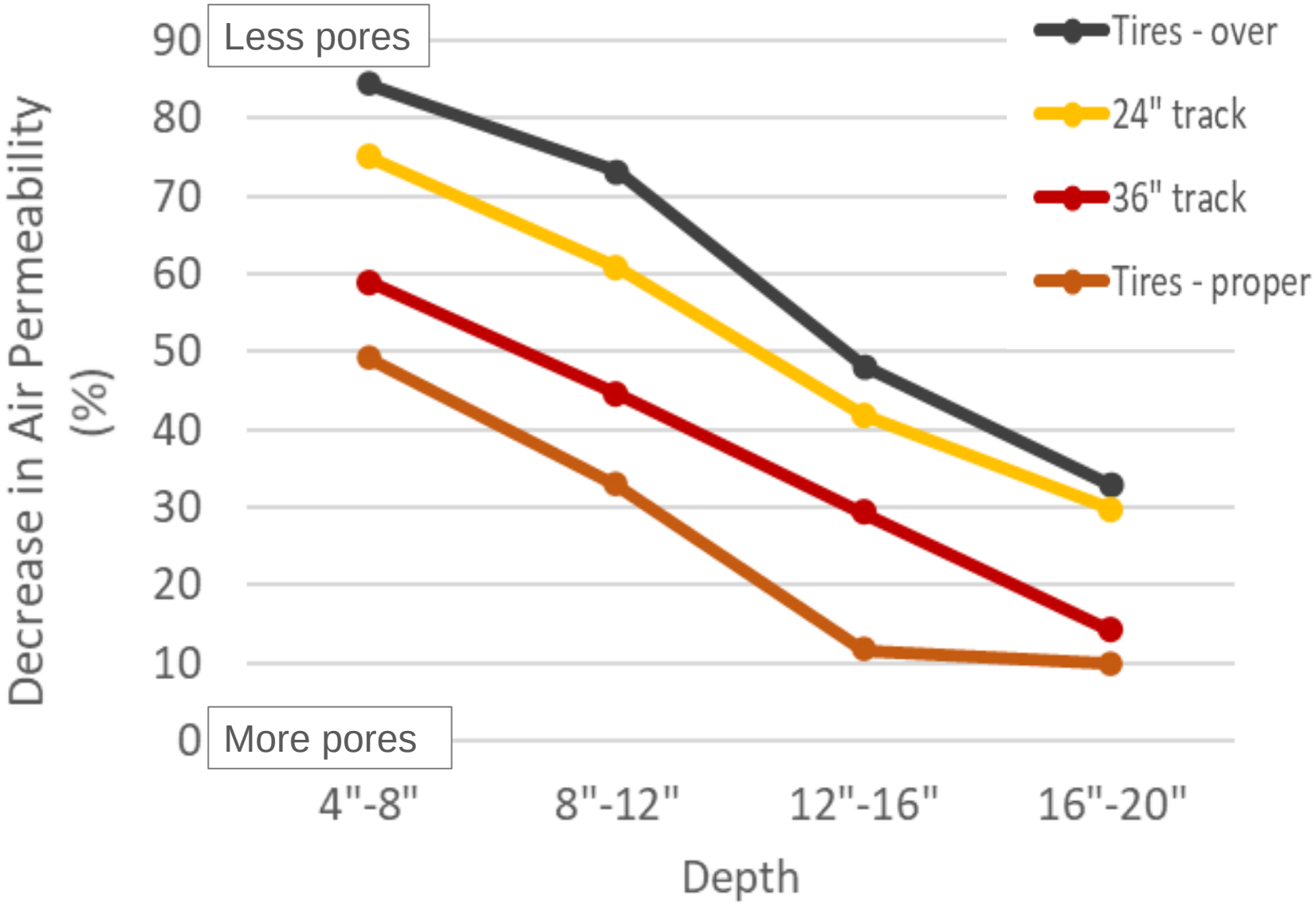
Slurry 6,000-gal Tank

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

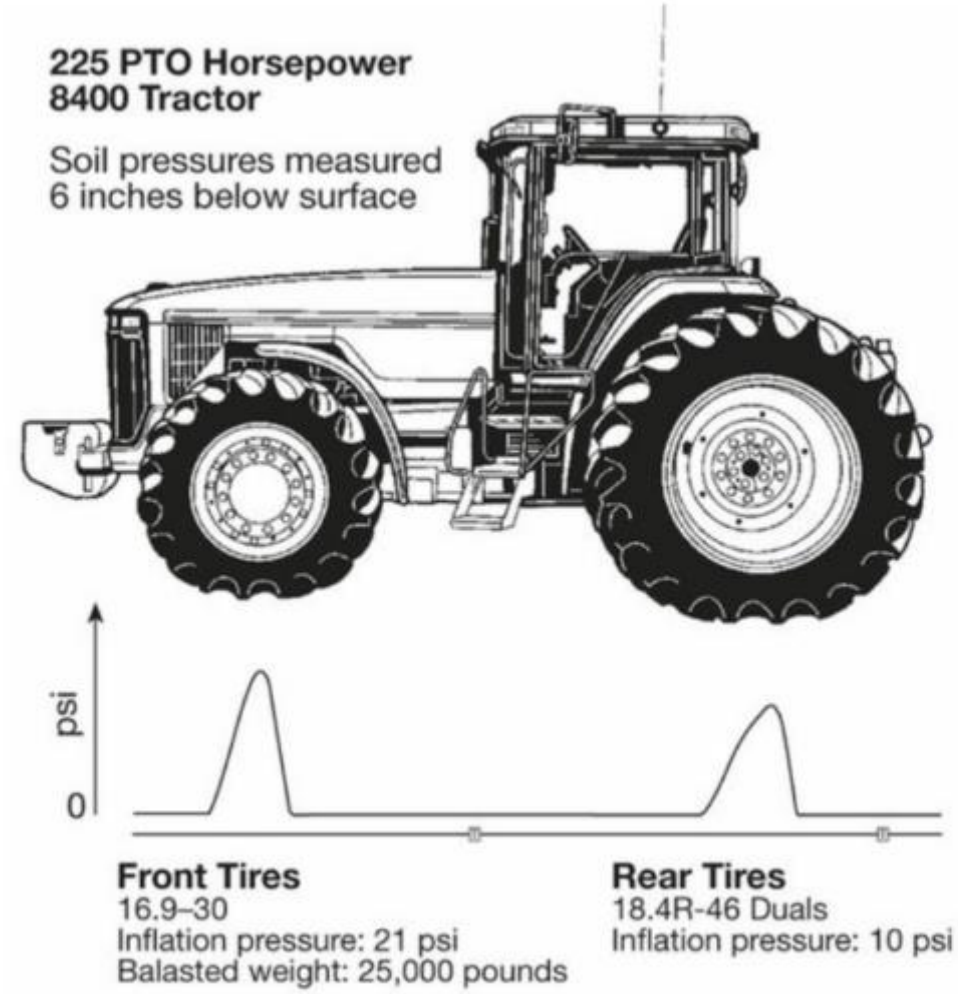
Lancas et al, 1996

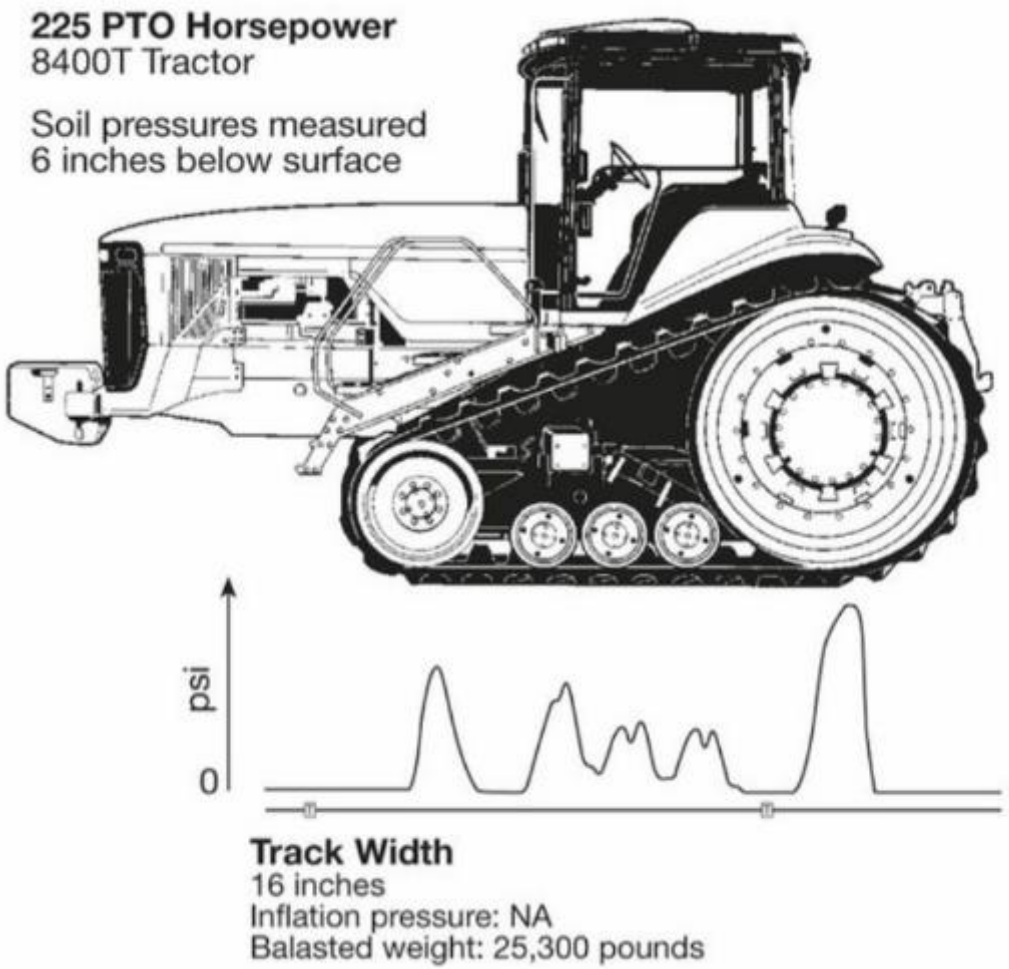


OSU Study

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

Abu-Hamdeh et al. 1995





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

Hoeft et al. 2000

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

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Unchecked Traffic Patterns

One vs Multiple Passes

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

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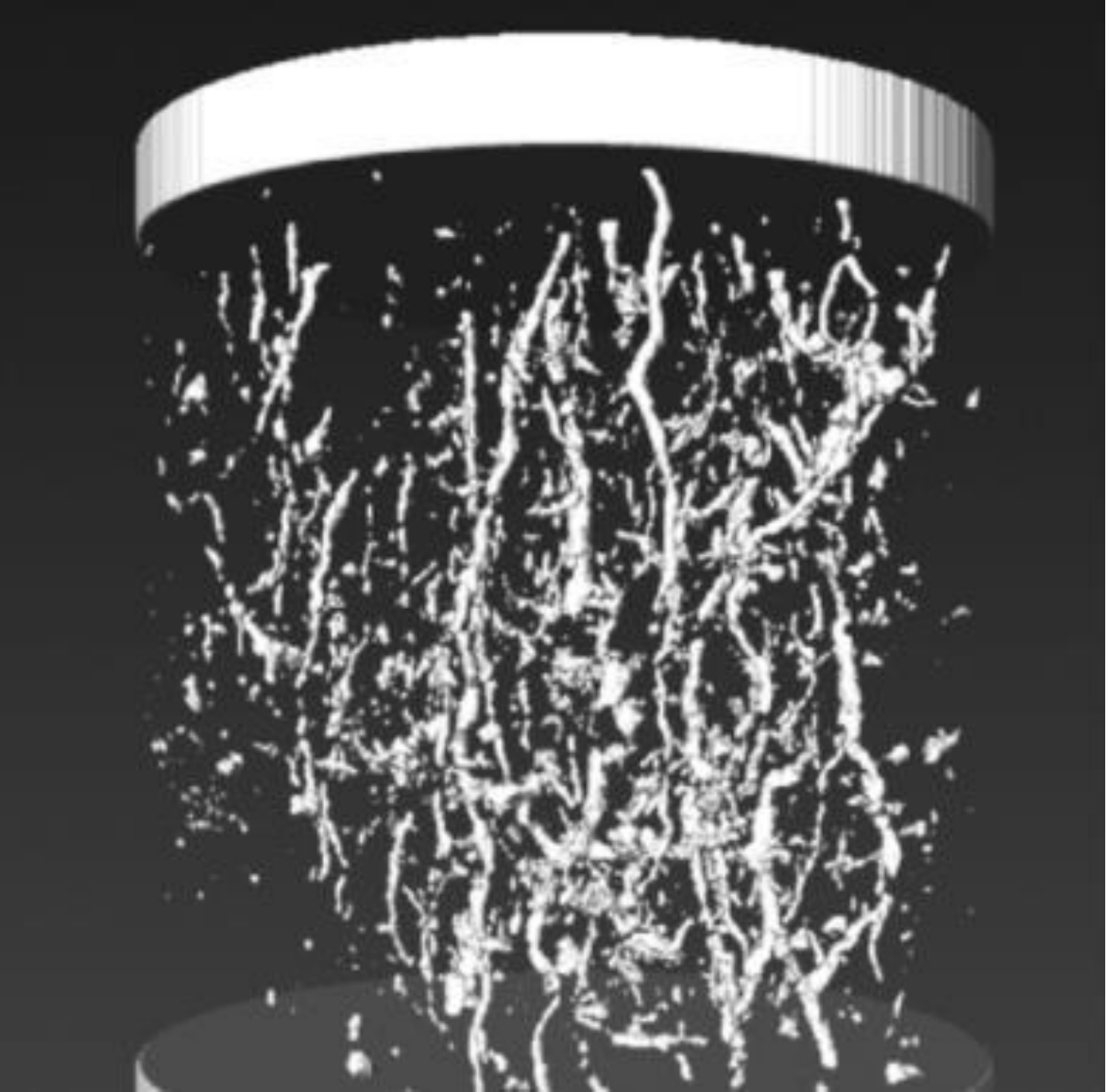
Lack of Soil Structure

#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

Schjønning et al. 2016 Soil Research;
Hirmas et al. 2018 Nature

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”

Jabro et al, 2021

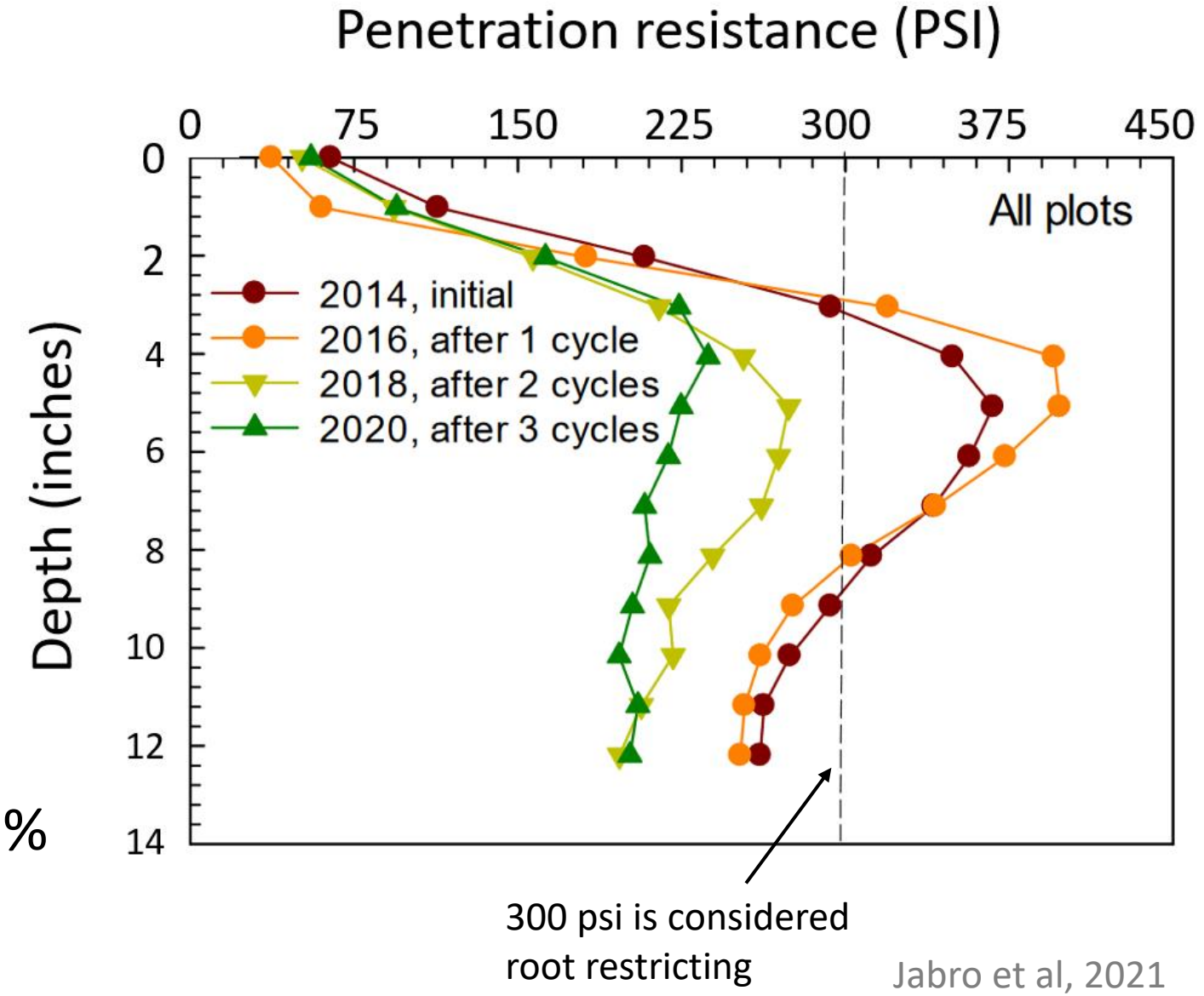
Cover Crops and Plow Pans

After 2 cycles (4 yrs)

- bd in plow pan ↓ 25%

After 3 cycles (6 yrs)

- bd in plow pan ↓ again by 32%



Jabro et al, 2021

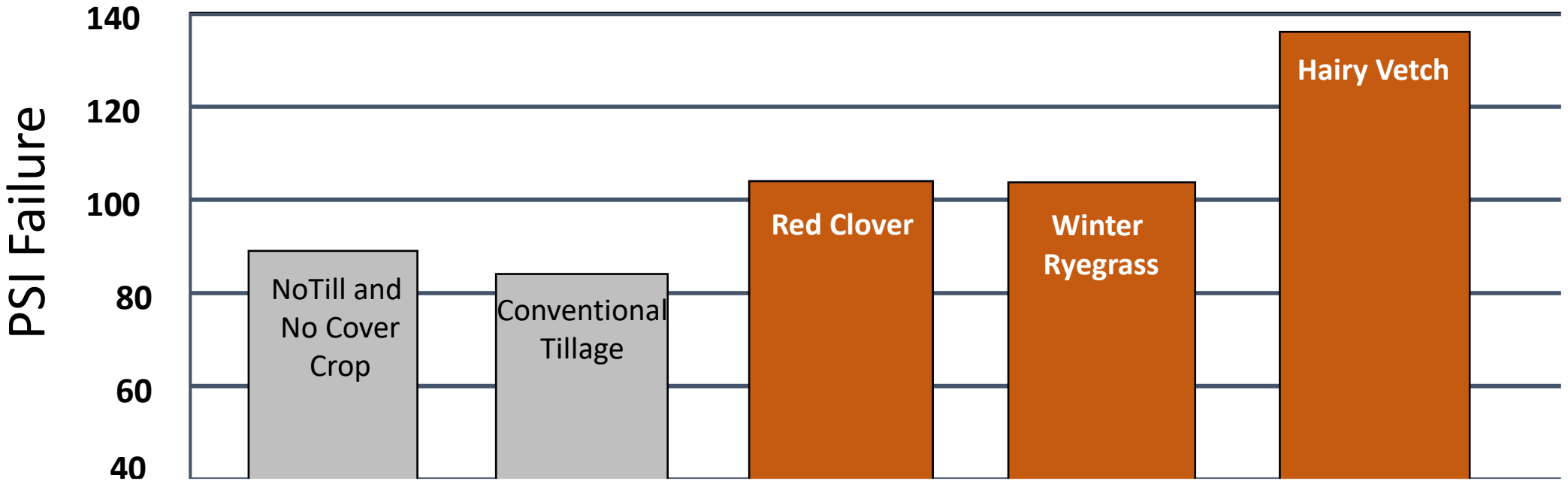
Soil Strength and Trafficability

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

Photos: Shannon Osborne, ARS

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

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z.umn.edu/TillageGuide
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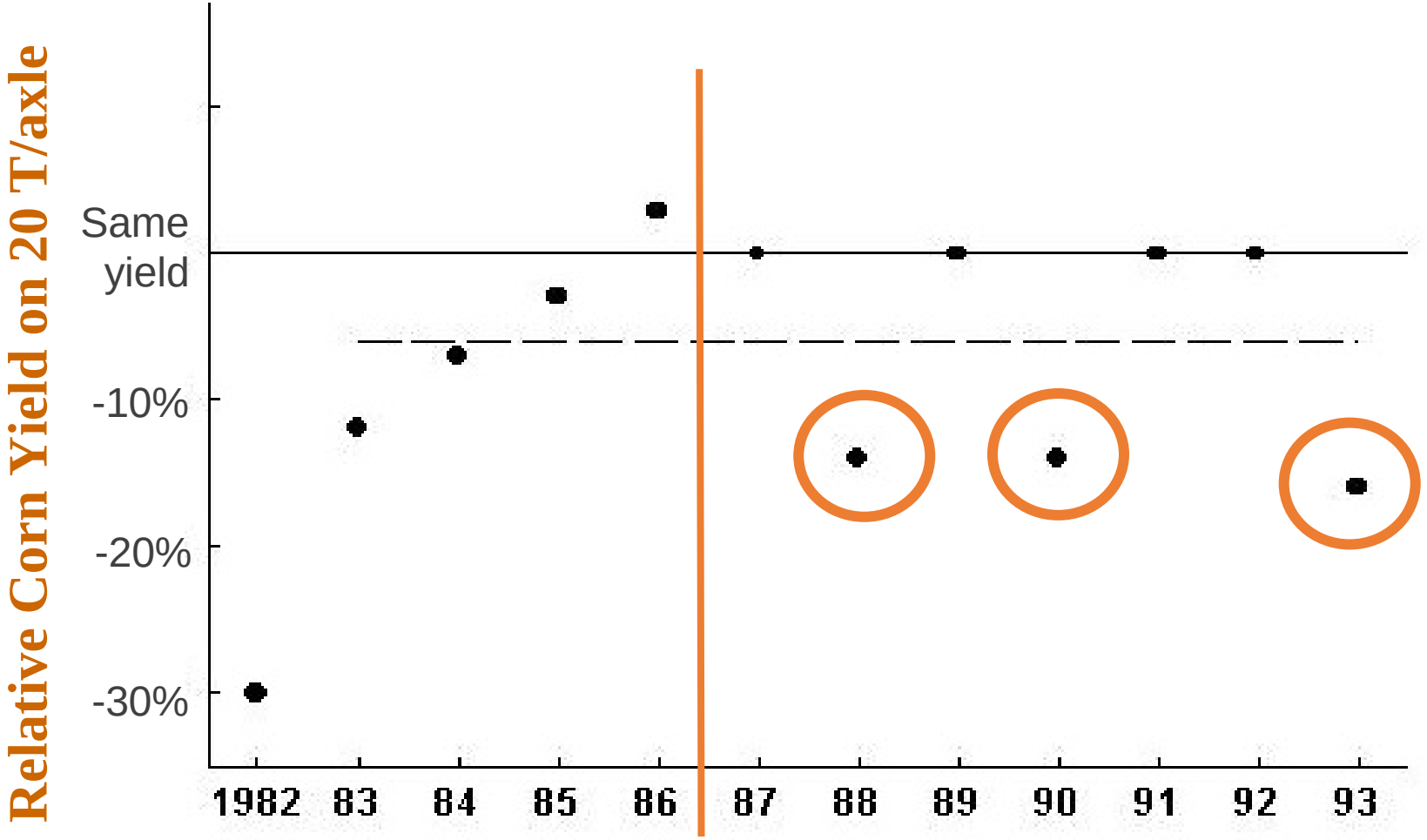
Aggregated versus Non-aggregated

- 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)



Ward Voorhees, USDA/ARS, Morris, MN

Extensive Wheel Traffic

Courtesy of Dan Smith, Gold Country

Yield reduced 24%

Wheel Traffic	45
No Traffic	59

-14 bu/ac

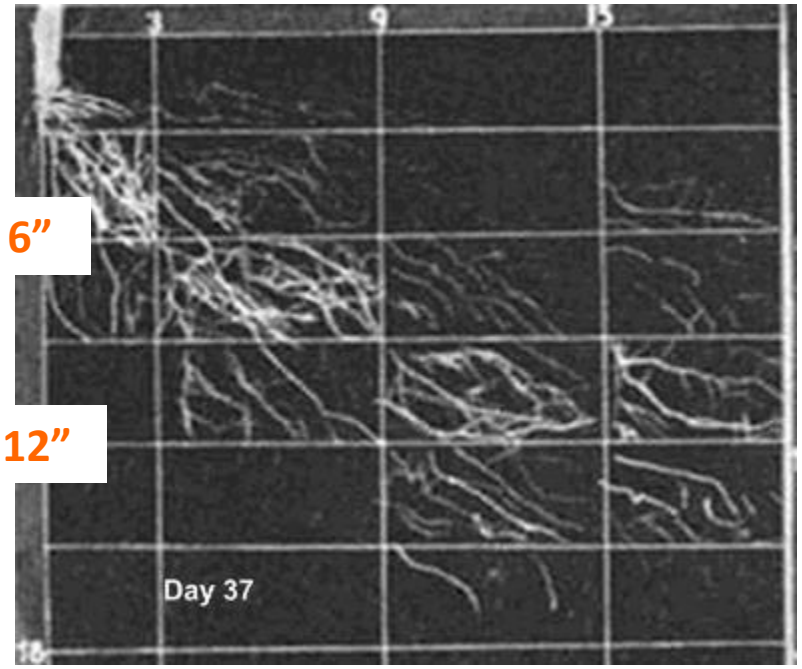
~80% of compaction happens on the 1st pass!

Nutrient Deficiencies

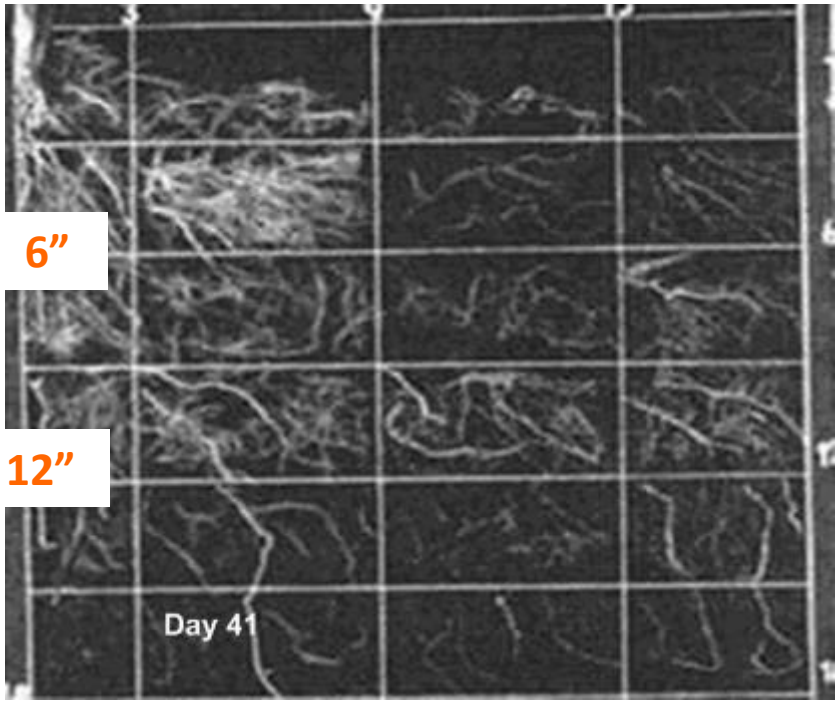
(esp. nitrogen and potassium)

Corn Root Growth

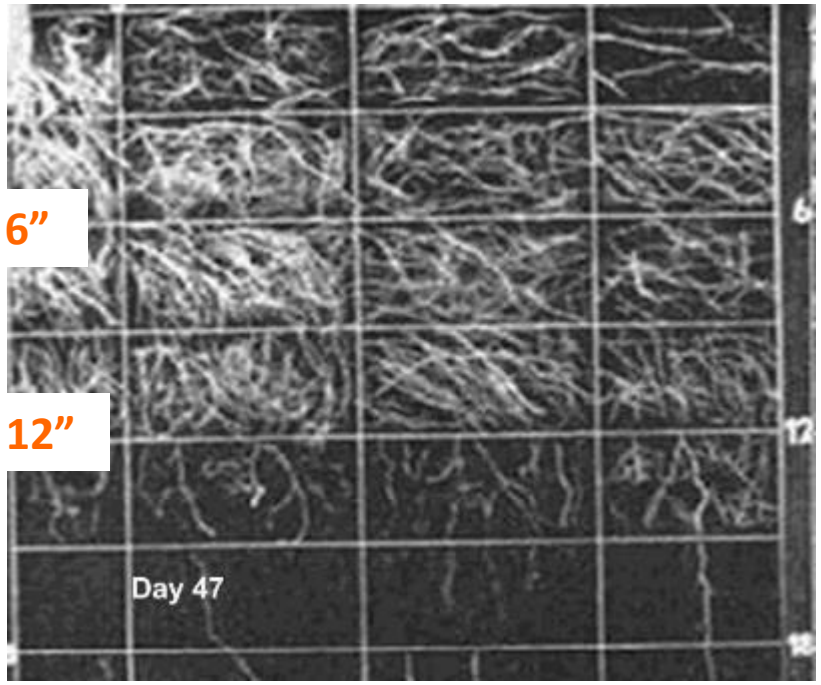
Day 37



Day 41



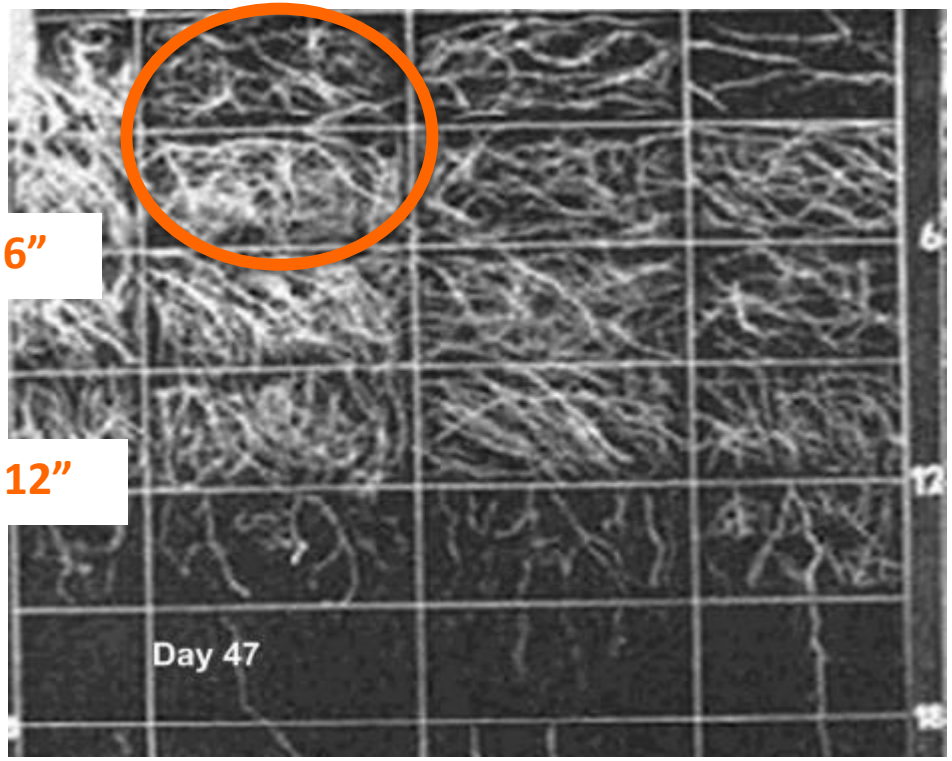
Day 47



Foth, 1962

Corn Root Growth with Wheel Traffic

Day 47



Foth, 1962