Soil management

NE Iowa, Harvest 2009

DeAnn Presley

12-01-2009

SW Area Update

3 topics I'm working on

- Residue removal
  - What's going on, effects on soil/soil-water
- Compaction
  - Types, Causes, Assessing, Addressing
- New vertical tillage implements
  - Use and benefits?

Abengoa Bioenergy

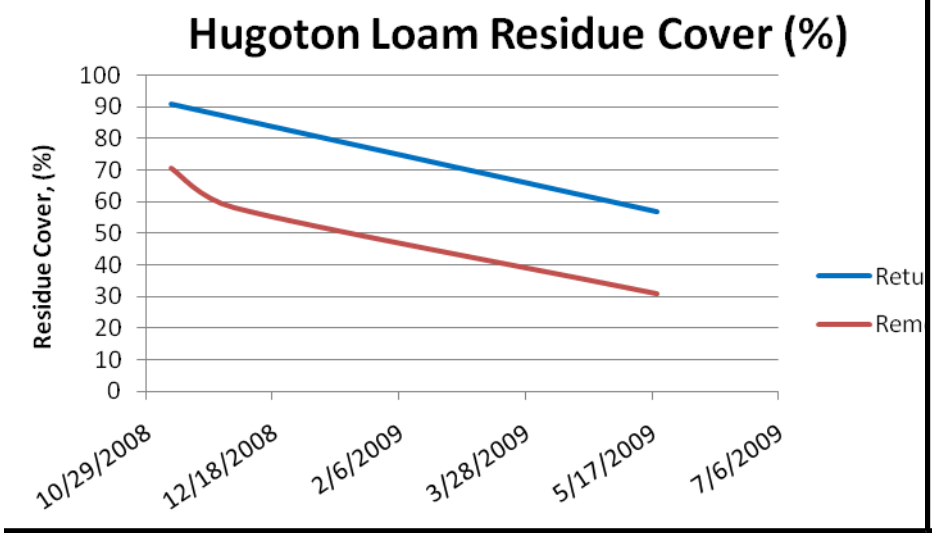
- Building an ethanol plant in Hugoton, supposed to break ground in 2010
- In 2008, the plan was to:
  - Produce ethanol from both grain and biomass (490,000 tons/year)
- Currently, the plan is to:
  - Only produce from biomass (875,000 tons/year)

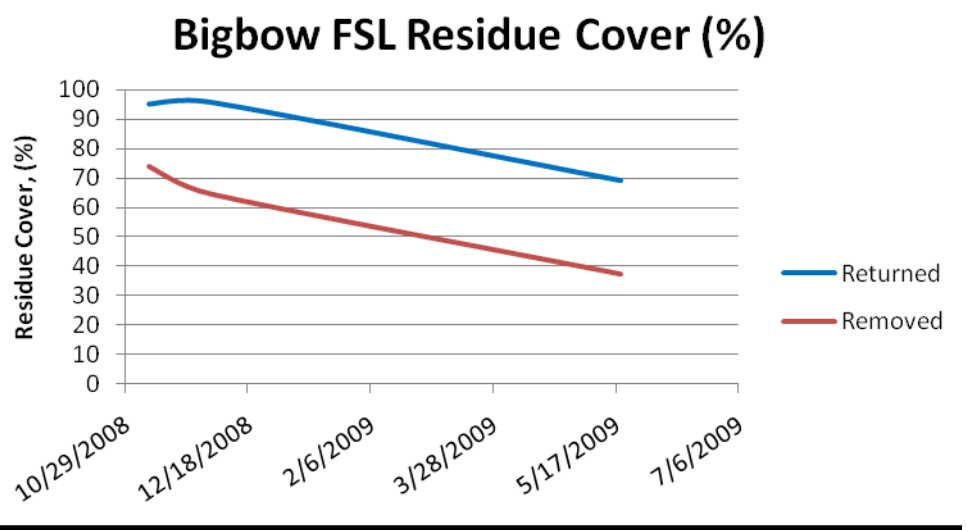
Note: 200 bu/ac corn ≈ 5.6 tons/ac residue and we need to leave at LEAST 30% of it out there for conservation compliance

Residue removal experiments

- 2008: Two soil types in Stevens Co
  - Practical removal method vs. no removal
    - Stalk-chop, rake, and bale took off 90% of residue
  - Strip-till, farmer-owned
- 2009: Ottawa, Colby, Hugoton
  - 5 levels of removal
  - NT at experiment fields, ST on farmer
- Objectives for both: Effects on continuous corn yields, soil properties, water dynamics

Residue changes throughout the winter



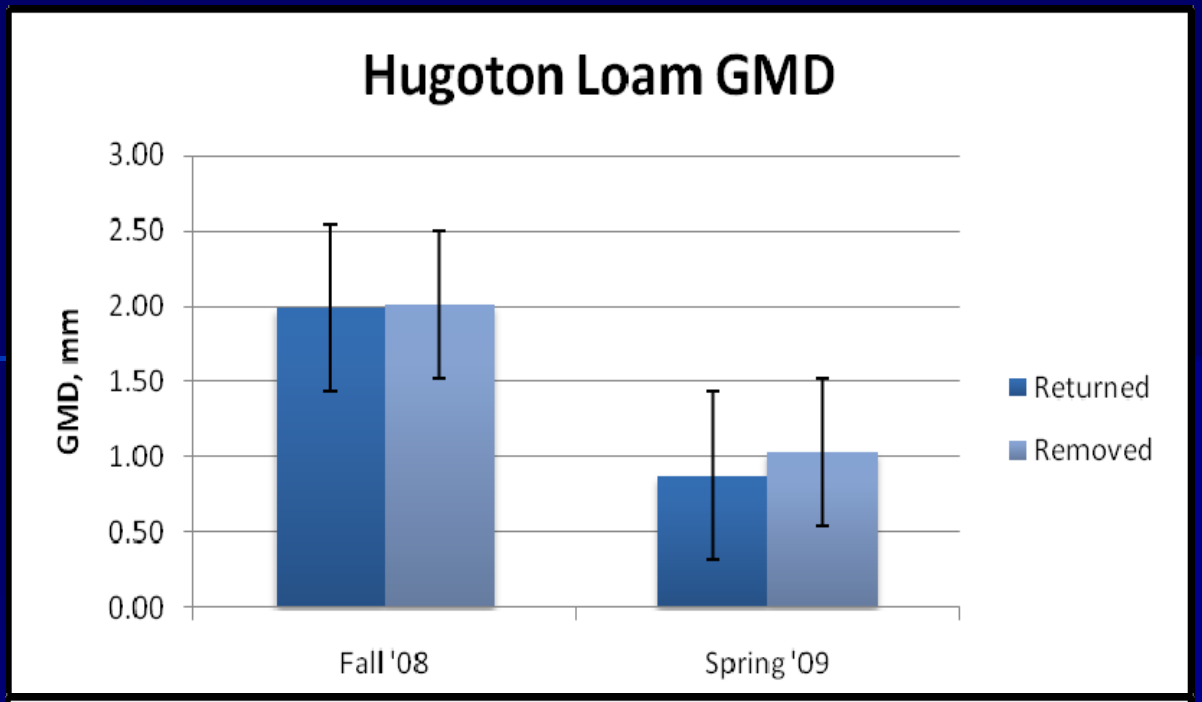


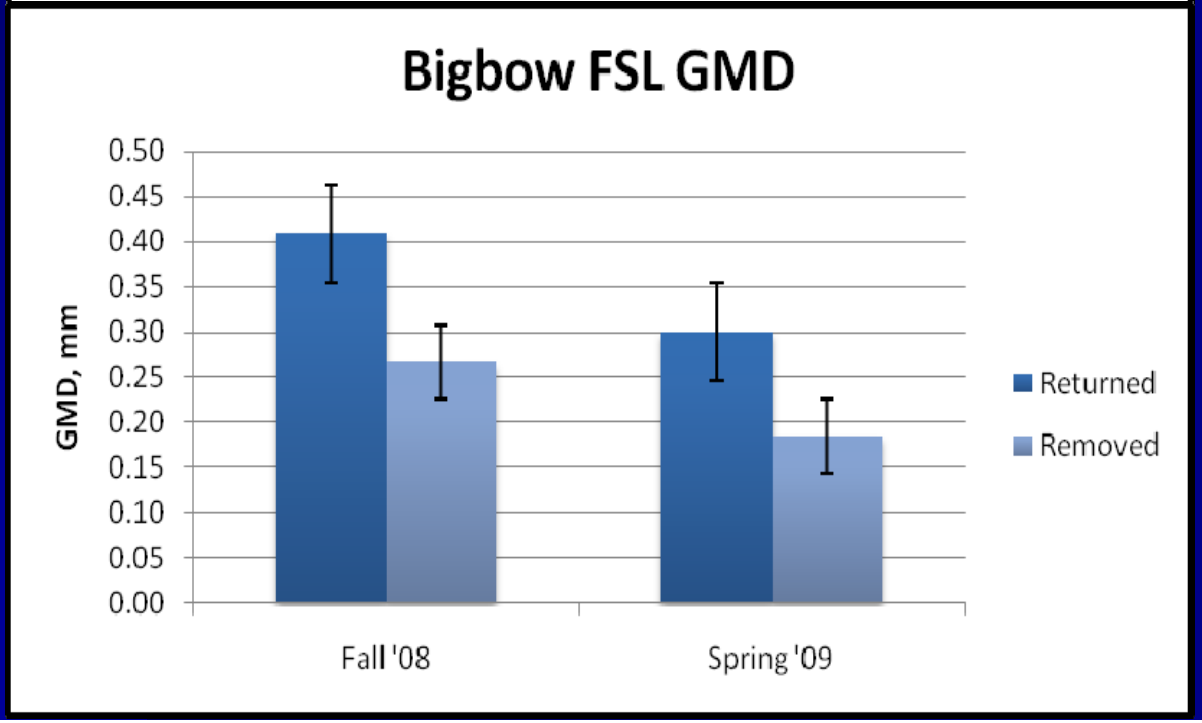
Residue levels dropped over the winter
20-30% for returned plots
30-40% for removed plots

Most people assume 10% loss over winter!!!

Why more loss for harvested? Because raking and baling removed the largest pieces of residue

30% is the bare minimum residue % for conservation compliance

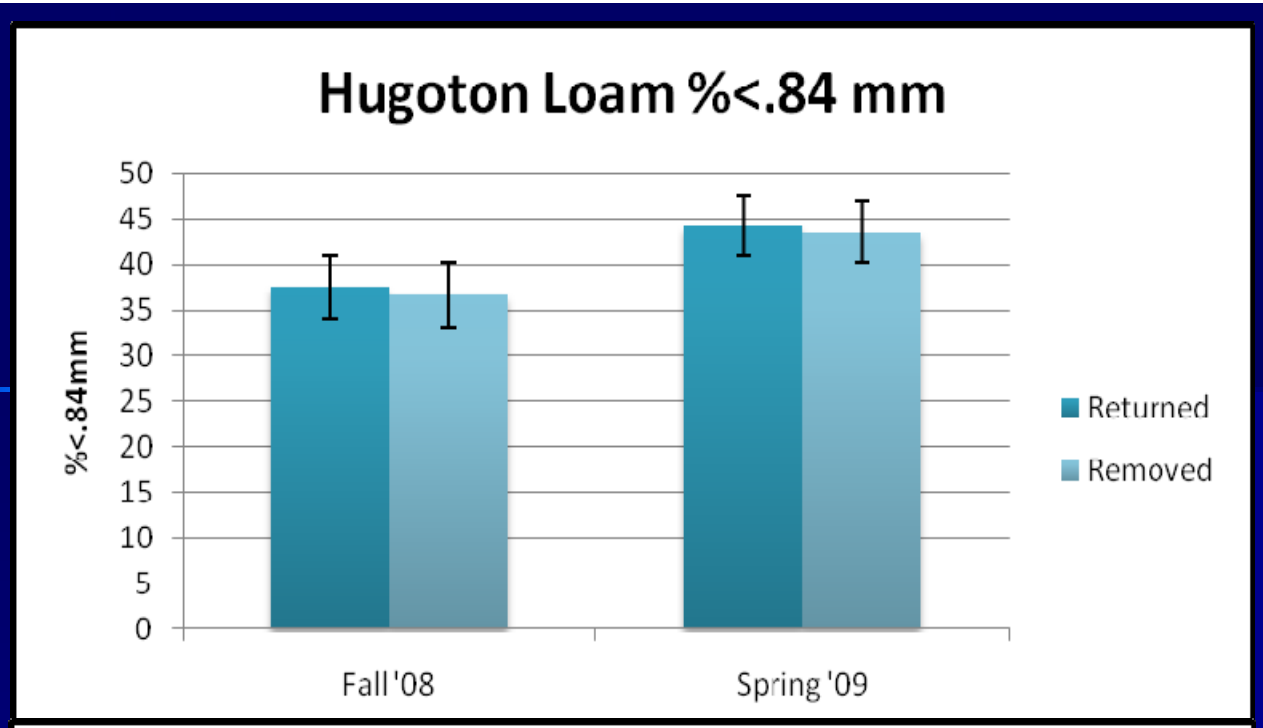


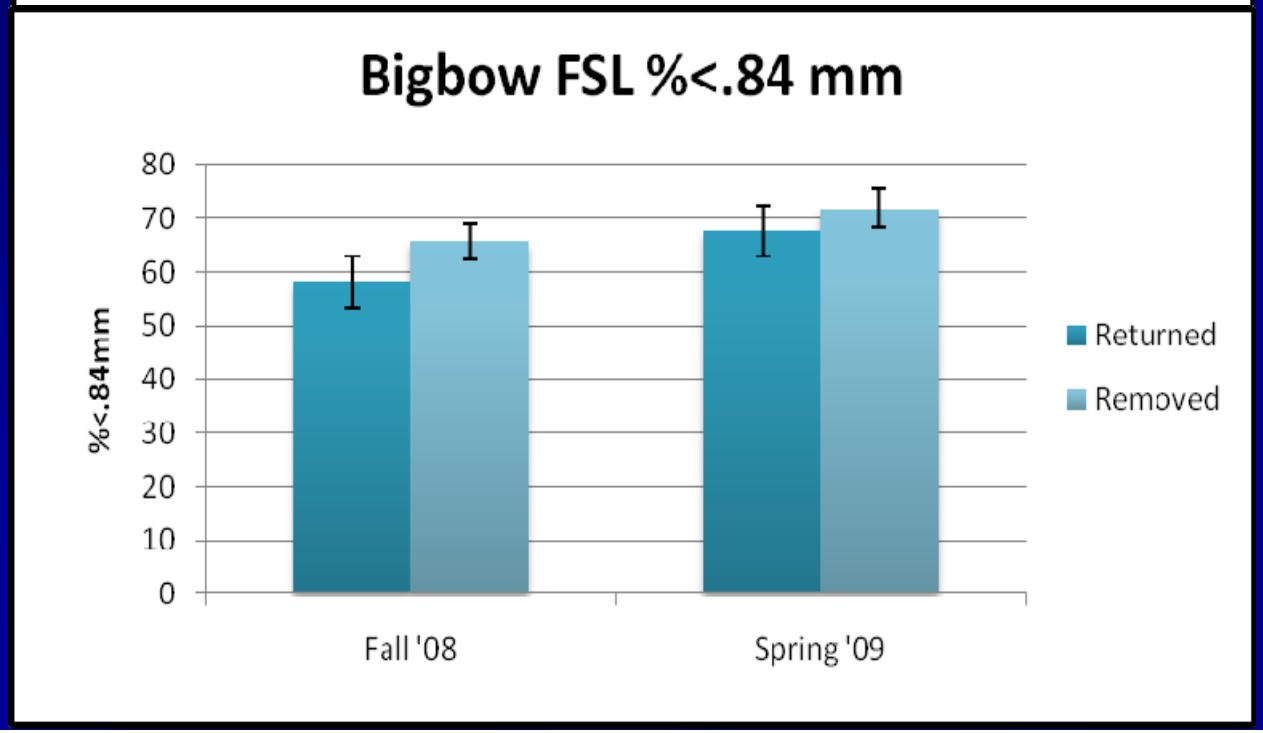


Aggregates (soil structure) got smaller during the winter

No effect of removal on loam

Significant effect on sandy soil

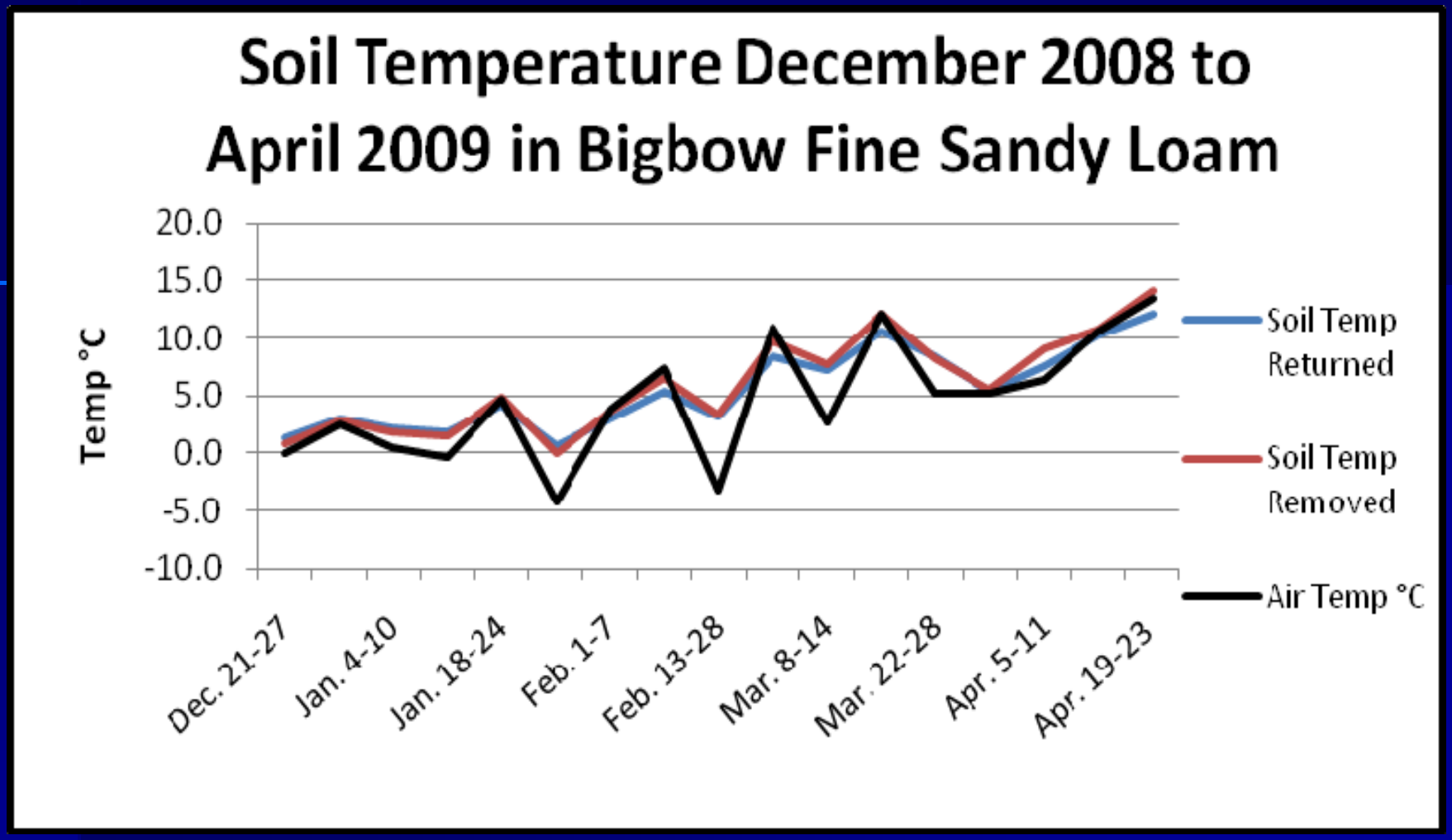




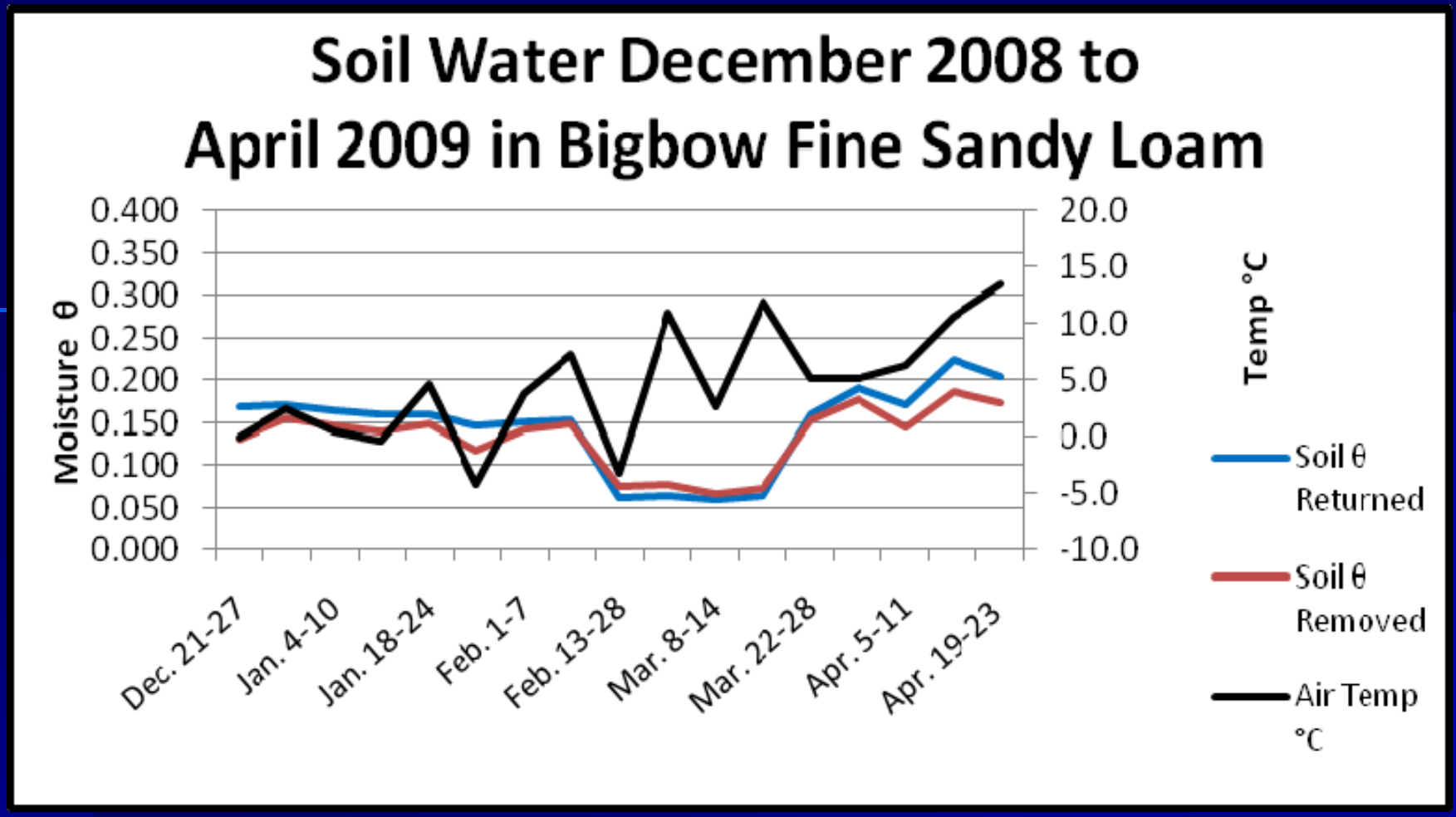
Wind erodible fraction:

Increased over winter

Residue removal worse for sandy soil



Soil temp generally warmer for plots w/out residue by ≈ 1°C, warm up slower when air temp increases



Plots w/out residue drier for most of this period

Freeze-thaw event in late January: Plots w/out residue froze, plots w/residue didn't

--This is why wind-erodible fraction increases over winter, structure deteriorates (but can loosen surface compaction, i.e, "mellow")

Soil Compaction

NE Iowa, Harvest 2009

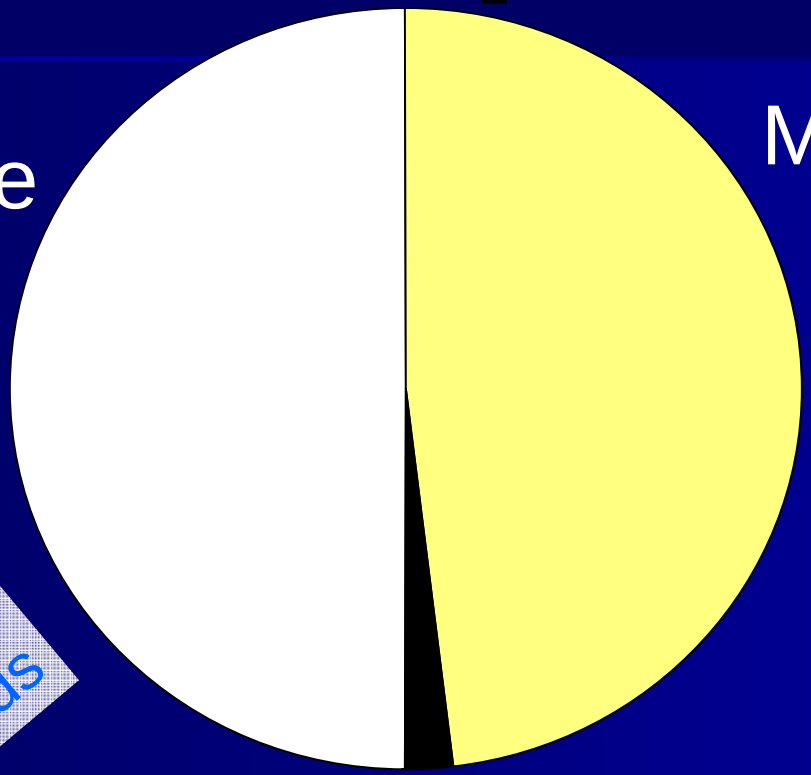
Top 10 Reasons to Avoid Soil Compaction

- Causes nutrient deficiencies
- Restricts root development
- Reduces soil aeration
- Decreases soil available water
- Reduces infiltration rate
- Increases bulk density
- Increases sediment and nutrient losses
- Increases surface runoff
- Damages soil structure
- Reduces crop productivity
  - Quantity depends on degree of compaction
  - Root restriction

Country	Soil texture	Crop	Yield reduction %
Canada	Clayey	Corn	70
Finland	Mollic gley	Oat, wheat, barley	1-4
Morocco	Clay loam	Wheat	23
Netherlands	Sandy	Corn sliage	38
Spain	Loam	Seed cotton	28
Sweden	Loam	Wheat	11
USA	Clayey	Corn	24
USA	Clayey	Sorghum	39
USA	Clayey	Oat	31
USA	Silt loam	Barley	14
USA	Silt loam	Pea	28
USA	Silt loam	Corn	14
USA	Clay loam	Corn	30

Ishaq, Ibrahim, and Lal, 2006

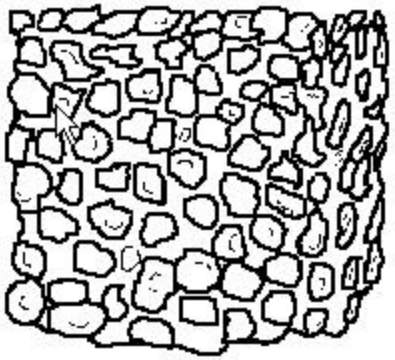
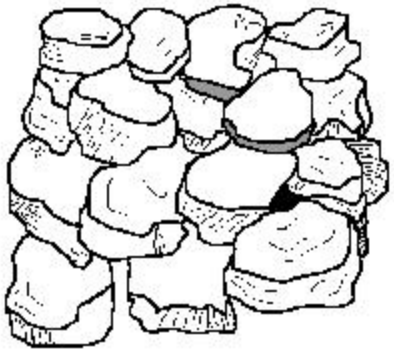
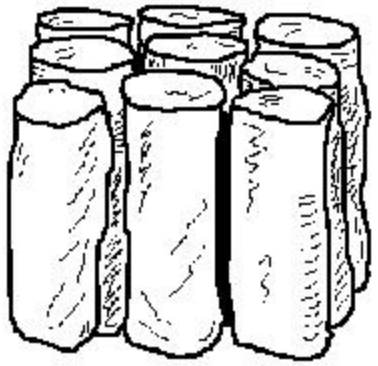
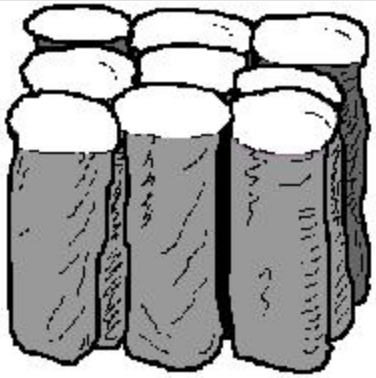
Soil Components



Pores contain gases and liquids

Soil structure

- Arrangement of soil particles into larger units
- Good structure= greater load-bearing capacity, better drainage

		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil. Soil Science Society of America	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Assessing compaction

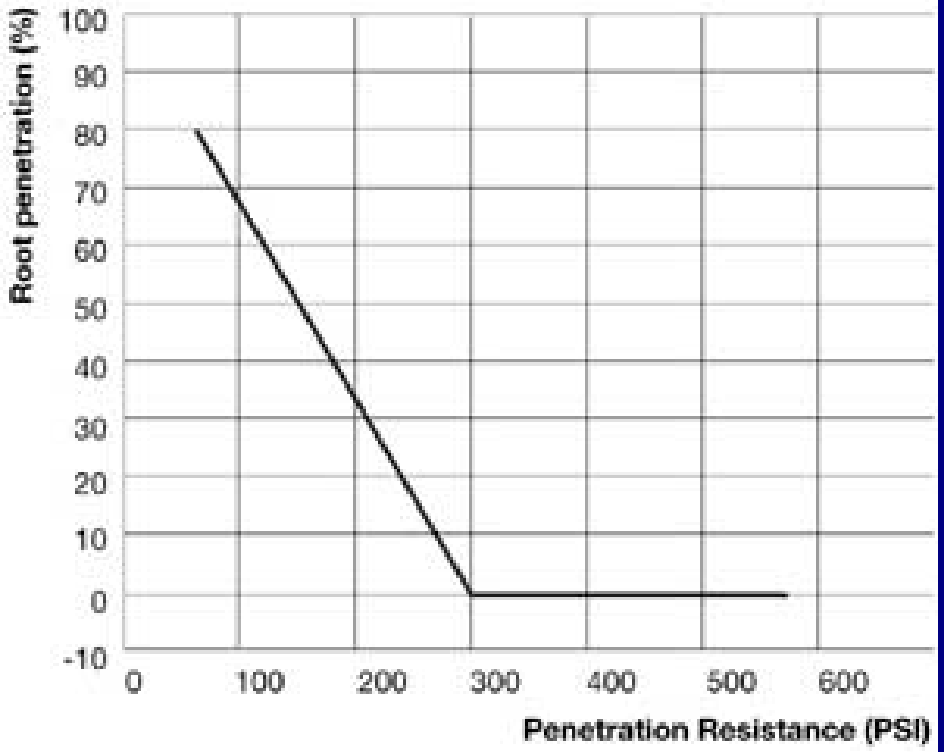
- Best tool is a spade or soil probe
- Look at soil structure, plant roots
- Determine exact depth (or location) where problem exists
- Use cone penetrometer if soils are at field capacity
  - 10 points per zone in field (endrows, soil type, etc)
- Make several observations

Penetration resistance

At field capacity, >300 psi is root limiting
Need to know moisture content, and something about soil properties to really understand this

Assessing compaction

Figure 2. Root penetration and penetration resistance.



The penetrometer simulates root growth. Root growth descreases linearly with increasing resistance, until practically stopping above 300 psi. Remember, however, that roots may still penetrate soil with a resistance greater than 300 psi if natural cracks and pores are present.

At FC

>300 PSI
(or >2000 kPa)

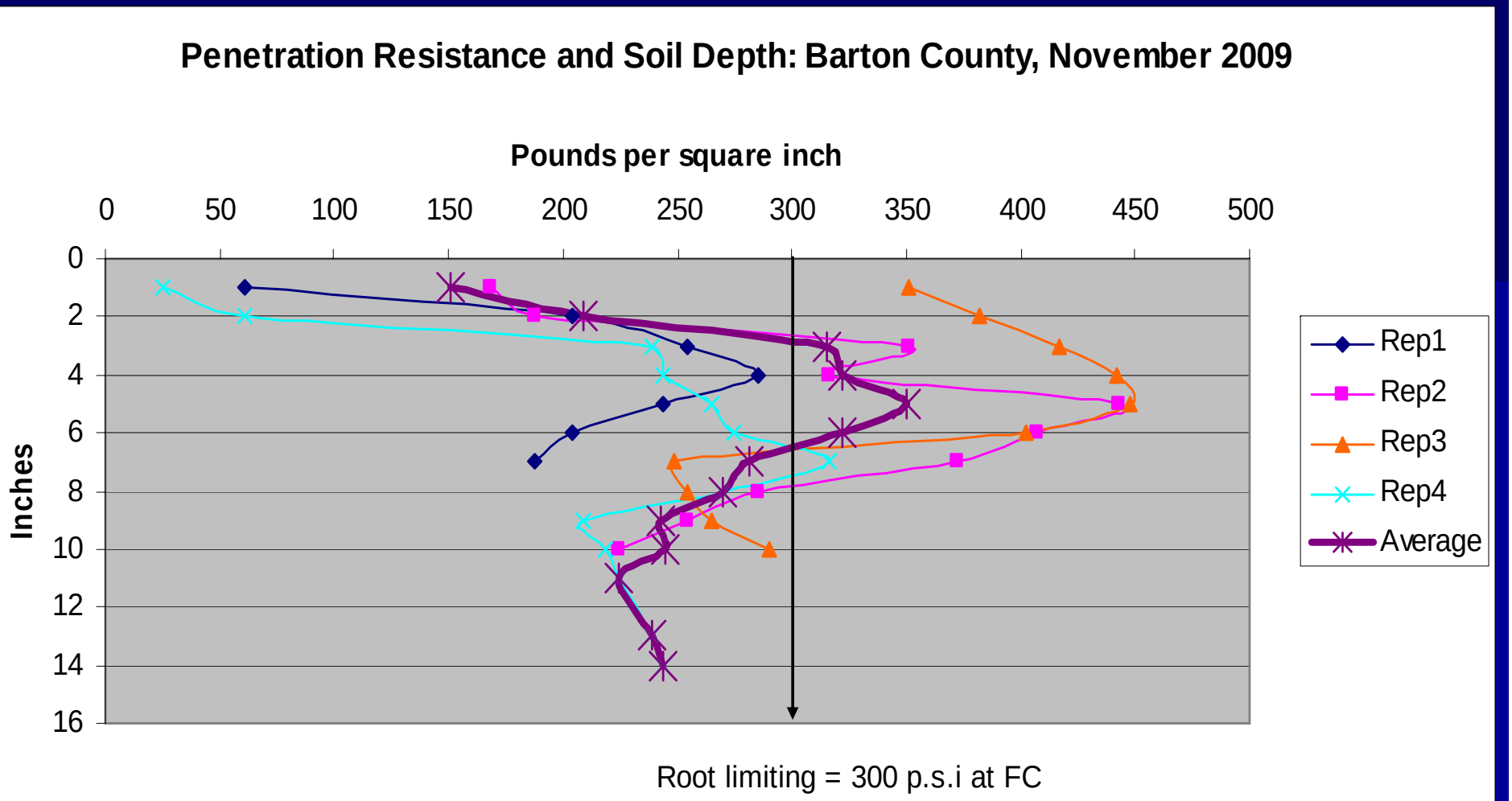
Is root-limiting

cropsoil.psu.edu

Surface crusts may prevent seedling emergence.

May be removed with freeze/thaw and wet/dry cycles.

Ray Ward



Average depth of compaction: 3 to 7 inches
NT since 2004, crops grown include wheat, sorghum, soybean
Grazing cattle on sorghum stalks

Surface compaction: 0-6”

- Caused by wheel traffic, animals
  - Cattle: 30 to 60 psi, affect upper 2--8” of soil
- Can be controlled by “spreading out” a load, either by using a larger tire or more tires, perhaps “new” tracks
- Tire pressure: 1-2 lbs greater than inflation pressure of the tire
- Usually removed with subsequent tillage operations or, usually by freeze-thaw and wet-dry cycles
  - How well this works depends on the weather, climate, on the cropping system, residue management, soils, etc.

Tillage-induced compaction: Depth of tillage

- Tillage implements that shear the soil, such as moldboard plows, disks, and sweep-type tools
- When continuously operated at the same depth, tillage implements orient soil particles in the same direction
- Potential to cause a tillage pan is greater under wet soil conditions than under dry conditions.

Tillage pan

Ray Ward

Sub-surface compaction: >6”

- Deep compaction is related to the maximum axle load, and is not reduced by distributing the weight across more tires or larger tires.
- Annual compaction with 10 ton axle load reduced corn yield by 17% in 3 out of 4 yr in a silt loam.
  - Pennsylvania (Duiker, 2006)
- Subsoil compaction is rare with axle loads under 5 tons and highly likely with loads greater than 10 tons per axle.

Subsurface compaction

- Axle weight is not reduced by distributing the weight between more tires on the same axle or using tires with larger footprints.
- Axle weight is only reduced by adding more axles
- Weight not always distributed evenly between axles

Heavy equipment

- What does a 1050-bu grain cart weigh?
  - Empty: 19,700 lbs
  - Grain: 1050 bushels of grain @ 56 lbs per bushel = 58,800 lbs
- Subtract 8,000 lbs transferred to tractor
- Total: 65,800 lbs
- Axle load = 35 tons (1 axle)

Tires: 520/85R38 (20.8" x 38")
7000 lbs at 23 psi, flat plate is 443 in^2

So surface pressure is 25 psi,
Axle load is 35 tons

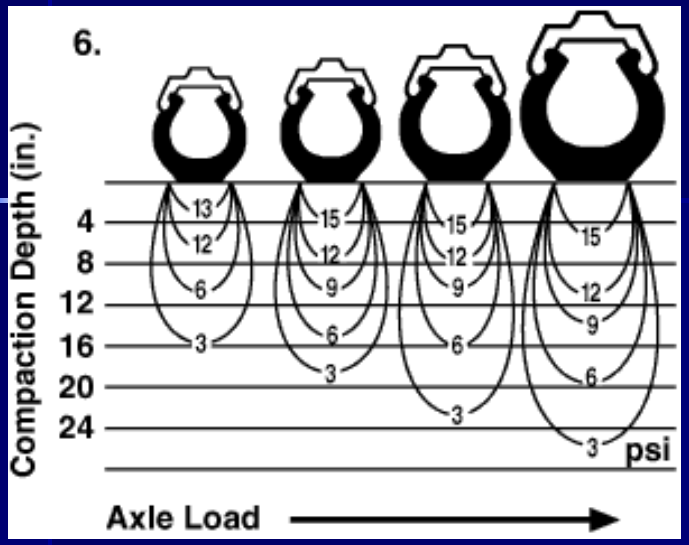
Specs: Kinze 1050 Row Crop Wagon

Approximate axle loads for field equipment

Equipment	Axle Load (Tons/axle)
Manure slurry tanker, 4,200 gal.	10-12
Manure slurry tanker, 7,200 gal.	17-18
12-row combine, empty	18
12-row, full with head	24
720 bu grain cart, full, 1 axle	22
Grain cart, 1,200 bu., 1 axle	35-40
Grain cart, 1,200 bu., 2 axles	17-20
4WD Tractor, 325 HP, front axle	13
4WD Tractor, 200 HP, front axle	7.5
MFWD Tractor, 150 HP, rear axle	6.5

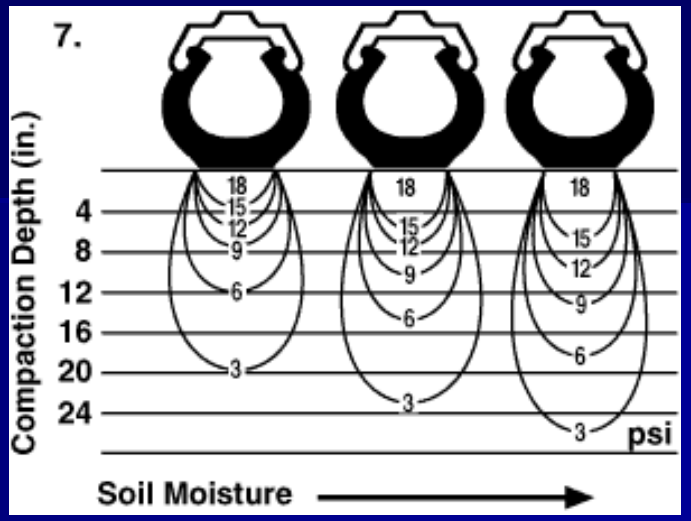
If less than 10 tons per axle, compaction is generally restricted to the upper foot or less of soil.

http://www.extension.umn.edu/



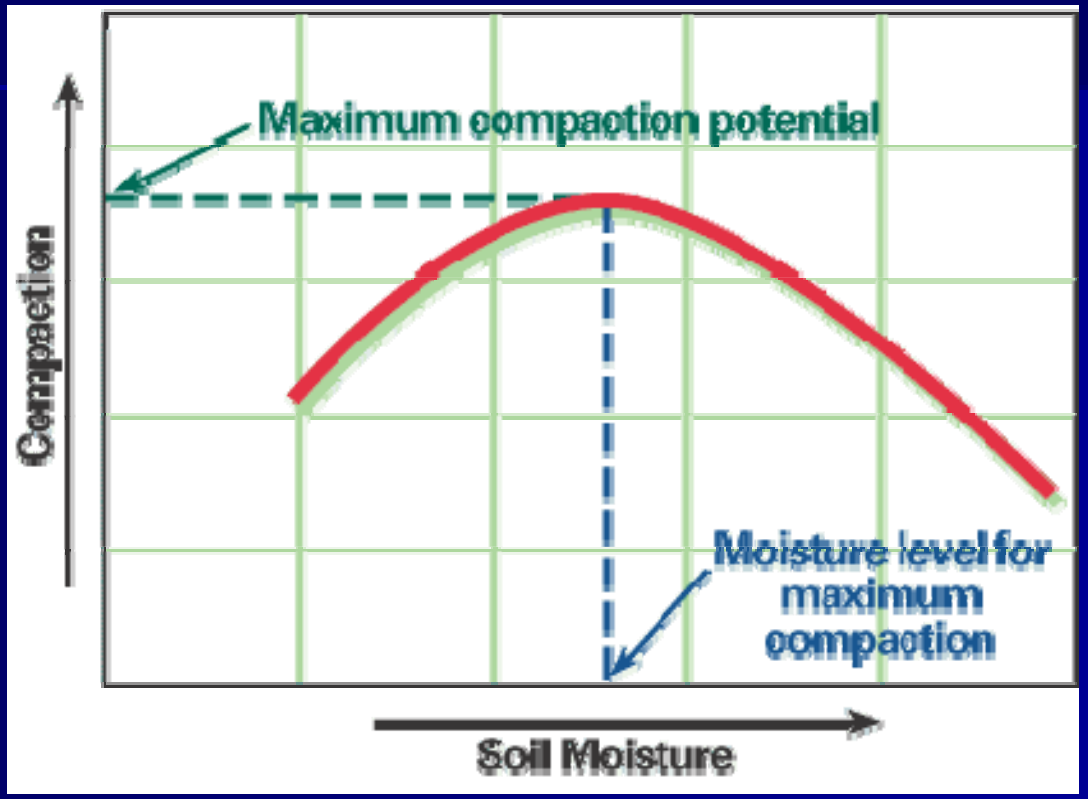
Adapted from Soehne, 1958

- The greater the axle load, the deeper compaction will travel in soil.



- Higher soil moisture means that soil will be compacted to a greater depth.

Moisture matters



www.extension.iastate.edu

"Ruts that look the worst are actually the best kind to have!"

Tracks or tires?

- Whether the equipment uses tracks or tires, the total axle load is nearly the same.
- Tracks will improve traction and ride-ability, but a 25-ton per axle grain cart will still create subsurface compaction
- “New” tracks: Configured better, first tracks still basically on 2 axles


BRENT
1394
BRENT


1394

Wheel traffic—Key point

- First pass of a wheel causes 70 to 90% of the total compaction (Gill, 1967)

Addressing compaction

- Besides prevention…
- Diverse crop rotation is one of the best solutions
  - Including any kind of taproot is beneficial
- Maintaining adequate residue protects surface, builds structure
- Does tillage work or does the benefit last?


10/12/2008

Cover crops and roots

Cover Root Channels May Alleviate Soil Compaction Effects on Soybean Crop (Williams and Weil, 2004, SSSAJ)

- Two possible reasons
  1. Forage radish provided low-resistance paths into the subsoil (biodrilling)
  2. Rye provided a mulch that limited evaporation from the soil surface and increased infiltration early in the growing season.

Tillage to address compaction

- Surface smoothing of ruts, rills, etc, use vertical tillage implement
  - Most farmers currently using multiple passes with field cultivator
- Surface (<8”) treat with a chisel plow
- Deep tillage defined as 16 to 20”

Smoothing harvest ruts

- Have to wait until soil is dry again
- One option is to leave it until next fall
- Cost/benefit:
  - Dealing with reduced yield for one year vs.
  - Spending time, energy to deal with it prematurely, possibly causing more damage in the process

When to deal with compaction: When soil is dry enough to shatter again (Stevens Co. Dec 2008)

How long does the benefit last?

- Depends on the producer
  - Traffic on field
  - If they work in wet conditions

Most studies, about 2 years (up to 5)

Subsoiling in conventional tillage: Ohio

- In a plow-based system
  - Primary and secondary tillage, at angles
  - Uncontrolled traffic
- Subsoil one fall
- How long does the benefit last?
- In 2 years, will have trafficked across 75% to 90% of that field (Reeder, 2006)
- Tilled soil is more compactable than well-aggregated soil

Does tillage pay?

- Bly (2002) analyzed 169 site years of subsoil tillage data in U.S.
- Subsoiling increased crop yield only when a defined restrictive layer was observed
  - +18 bu corn
  - +7 bu soybeans
  - +10 bu wheat
- Not economical if there was no compaction
- More economical in SE U.S. (low o.m. soil, non shrink-swell clays)

Ottawa, KS study (Keith Janssen)

Tillage system and frequency	*Corn 6 yr avg*	*Soybean 6 yr avg*
No-till	98	35.4
Chisel every year	100	36.6
Subsoil every year	103	37.0
Subsoil every other year	99	37.3
Subsoil every third year	105	37.9

Note: These yields are not statistically different.

Chisel: 5 to 7 inches
Subsoil: 8-14 inches

Averaged across all six years, which included both average and below average moisture years.

Simple math here:
If yield isn't different, Economics aren't either

Subsoiling facts

- Subsoiling when it is too wet will only move the compaction zone deeper
- Must wait until very dry (right after harvest?)
  - If this fall is too wet, have to wait for the next dry opportunity
- Cause fracturing
- Only go 1” below the current zone
- Shank spacing=depth of compaction
- Power requirement quadruples as depth is doubled

Vertical tillage

Case, Great Plains, Landoll, Salford, etc.


CASE IH
09/16/2009


09/16/2009

Vertical tillage
(Presley and Hallauer, 2009)

Physical Properties	Depth (in)	VT mean	NT mean	p-value, t-test**
Bulk density (g cm^{-3})	0-2	1.13	1.21	**0.08**
	2-4	1.29	1.30	0.92
Mean Weight Diameter (mm)	0-2	1.44	1.62	**0.04**
Infiltration (mm hr^{-1})*	Surface	21.4	44.0	**0.04**

No emergence, stand, or yield differences in 2009 soybeans.
This field had beautiful soil properties to begin with,
NT since the 1980's

Avoiding compaction

- Stay off wet soil
- Properly inflate tires
- Reduce the load size (<10 tons)
- Consider controlled traffic
- Use a crop rotation
- Increase crop residues
- Increase soil organic matter to improve soil structure

Summary: Types and causes

Type	Cause	Remedy
Surface	Raindrop, traffic, animals	Residue cover, freeze thaw, decrease tire pressure, floaters, duals
Shallow subsurface < 8”	Tillage Planter	Vary tillage depth or eliminate tillage Don’t work when wet
Deeper subsurface 8-30”	Axle load	Reduce axle load to under 10 tons in field (keep heavy equip in endrows)