ADDRESSING THE SOIL COMPACTION PROBLEM

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SOIL COMPACTION DEFINED

Compression of the soil from an applied force that first re-arranges and then destroys aggregates increasing bulk density and reducing porosity

- Wheel traffic from field operations
- Tillage
- Livestock
Soil compacts when load-bearing strength of soil is less than load being applied.
“COMPACTABILITY” INFLUENCED BY WATER CONTENT

- Varies by soil
- Maximum near field capacity
- Dry soil has more strength
- Saturated soil not as compactable

Proctor Test Results

![Graph showing Proctor Test Results with dry soil strength and water content relationship.](image)

![Images of soil compactors.](images)
**COMPACTION IS A PROCESS**

- **$D_b = 1.0$**
  - Large aggregates
  - Loose condition
  - Many large pores
  - Well aerated
  - Just after tillage

- **$D_b = 1.3$**
  - Firm condition
  - Few large pores
  - Moderate aeration
  - Typical silt loam
  - Following normal traffic

- **$D_b = 1.6$**
  - Very tight, compact
  - No large pores
  - Small pores are water-filled
  - Crushed aggregates
WHY IS COMPACTION AN ISSUE

- Larger equipment
- Earlier field operations traffic
- Loss of forage in rotation
- Operations on wet soils
- Time management
- Uncontrolled
- Brain cramps
Will more tires spread weight ... or allow operations in wetter conditions and compact a greater soil volume?
WHICH IS WORSE – PRESSURE OR LOAD?

High PSI, but small load       Low PSI, but large load

THE GREATER THE LOAD THE DEEPER THE COMPACTION EFFECT
**TRACKS vs. TIRES**

Compare total load per axle

- Track have many axles

5,200 lb (2359 kg)/axle

18,200 lb (8256 kg)/axle (Rear)

9,800 lb (4445 kg)/axle (Front)
I'VE GOT PLENTY OF COMMON SENSE!

I JUST CHOOSE TO IGNORE IT.
There really are days you shouldn’t be in the field!
Chasing the combine is an old habit

SOIL SURVEY
Greeley County, Kansas
CONTROL PHEASANTS
COMPACTION BY UNLOADING IN HEADLANDS
MANAGING COMPACTION WITH CONTROLLED TRAFFIC FARMING
CONTROLLED TRAFFIC FARMING CONCEPTS

- Recognizes random traffic-induced compaction is bad
- Adapts machinery and organizes operations to have trafficked and non-trafficked zones
- Creates permanent “wheelways”
- Utilizes wide-span implements and GPS guidance
- Requires careful planning and
CONTROLLED TRAFFIC FARMING

- Practiced extensively in Europe and Australia
- Modified 3 m width tractor
- GPS guidance
- Preserves soil quality between lanes
- Why not?
  - Variety of operations
  - Equipment cost
  - Field shape
MOST OF THE COMPACTION OCCURS IN THE FIRST PASS

- Plano silt loam
- Soil near field capacity (34 – 38%)
- 2007 NT w. wheat
  2006 NT corn silage following alfalfa
- Chisel vs. None
- No traffic or 1, 2, 4, and 6 passes with a 14.5 ton combine
- 6 measurements per treatment

Arlington Evaluation
EFFECT OF NUMBER OF WHEEL TRAFFIC PASSES ON SOIL COMPACTION

**Chisel Plowed**

**Not Plowed**
WHEEL TRACK EFFECTS ON PENETRATION RESISTANCE

Chan et al., 2006
# TRAFFIC EFFECT ON SOIL PROPERTIES AND YIELD

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Canola</th>
<th>Wheat</th>
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<tr>
<td></td>
<td>WT</td>
<td>Non-WT</td>
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<tr>
<td>Bulk density (g/cc)</td>
<td>1.58</td>
<td>1.29</td>
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<tr>
<td>Air-filled pores (%)</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>Root density (g/m3 x 1000)</td>
<td>9.2</td>
<td>27.5</td>
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<tr>
<td>Biomass (Mg/ha)</td>
<td>4.7</td>
<td>11.8</td>
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<tr>
<td>Yield (Mg/ha)</td>
<td>1.1</td>
<td>3.2</td>
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<tr>
<td>Harvest index</td>
<td>22</td>
<td>27</td>
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*Chan et al., 2006*
EXAMPLES OF CTF SYSTEMS

Figure 1. ComTrac. A CTF system that uses a single common track width to match the widest vehicle. Implements all have a common span or direct multiple of it.

Chamen, 2005
ADAPTING CTF TO IRREGULAR AND SLOPED FIELDS

Grassed buffer/waterway

Chamen, 2005
COMMON SYMPTOMS OF SOIL COMPACTION

SOIL:
- Standing water
- Excessive runoff
- Structural degradation (clods)
- Difficult to work

PLANTS:
- Stunting/uneven growth
- Nutrient deficiency symptoms
- Malformed roots
- Reduced yield
Pea harvest: Vegetable crop contracts often lead to soil abuse
Utility construction projects
“Cloddy” soil following corn silage harvest
Cloddiness re-defined
Stunted, uneven stand is often the first symptom
The shovel is an excellent diagnostic tool.
GROWERS ARE INTERESTED IN COMPACTION MANAGEMENT

Northeast Wis. field day
Excavated plow layer
“Pancake”
root mass
QUANTIFYING COMPACTION

• CROP AND SOIL SYMPTOMS

• PENETRATION RESISTANCE
  – Moisture dependent
  – No absolute value
  – Note depth and relative force
  – Compare good and bad areas

• BULK DENSITY
  – Mass per volume
  – Calculate porosity
  – Texture dependent
MEASURING PENETRATION RESISTANCE

Hand-held penetrometer

Soil probe
Response of a Plainfield sand to compaction and deep tillage, Hancock, Wis.
EFFECT OF COMPACTION ON SOIL BULK DENSITY OF A PLANO SILT LOAM

<table>
<thead>
<tr>
<th>DEPTH</th>
<th>COMPACTION</th>
<th>YEAR 1</th>
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<th>YEAR 3</th>
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<tr>
<td>in</td>
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<td></td>
<td></td>
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<td>0 – 6</td>
<td>NO</td>
<td>1.19</td>
<td>1.30</td>
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<td>6 – 12</td>
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<td>1.31</td>
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<td></td>
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<td>1.59</td>
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<td>12 – 18</td>
<td>NO</td>
<td>1.19</td>
<td>1.35</td>
<td>1.33</td>
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<td>1.36</td>
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<tr>
<td></td>
<td>YES</td>
<td>1.40</td>
<td>1.34</td>
<td>1.33</td>
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Compacted in year 1 and seeded to alfalfa
COMPACATION AFFECTS NUTRIENT UPTAKE

Potassium Affected Most

- Compaction reduces porosity
- Lowers soil oxygen
- $O_2$ needed for root respiration and active uptake
COMPACTION EFFECT ON CORN YIELD ON A SILTY CLAY LOAM SOIL

Oshkosh, Wis.
RESPONSE OF CORN TO ROW-APPLIED K ON A SILTY CLAY LOAM SOIL (3 yr. avg.)

Oshkosh, Wis. (45 lb K₂O/a)
IS COMPACTION A PROBLEM IN FORAGE PRODUCTION

- Compaction limits growth and yield
- Potential high in forage production
  - Fertilizer and lime applications
  - Liquid manure
  - Normal management = many traffic passes
  - Harvest on wet soils
- K/compaction relationship
- Alfalfa has a high K need
Alfalfa winter-kill resulting from wheel traffic
EFFECT OF COMPACTION ON ALFALFA YIELD ON A SILT LOAM SOIL

Arlington, Wis.
K SOIL TEST AND ALFALFA YIELD ON A COMPACTED SOIL (sum of 3 yrs.)

Arlington, Wis.

SOIL TEST K

YIELD (t DM/a)

< 5 t

11

10

9

8

14 t

OPT HIGH V. HIGH
DETERMINING THE NEED FOR SUBSOILING

- Evaluate depth and severity of compaction
- Check with penetrometer, probe, shovel
- Dig plants to examine roots
- Leave untreated strips for comparison
- Subsoiling is not a cure-all
OTHER SUBSOILING CONSIDERATIONS

- Burial of crop residue
- Destruction of natural channels
- Sidewall smearing
- May bring stones, clay, infertile soil to the surface
- Does not address compaction cause
EFFECT OF TILLAGE AND K FERTILIZATION ON FIRST-YEAR CORN YIELD AFTER SOYBEAN (2 yr. avg.)

Arlington, Wis.
WHICH TYPE OF SUBSOILER

“V-Ripper”
- Leading disks
- Parabolic shanks
- Winged points

“Conservation”
- Cutting coulters
- Straight shanks
- Horizontal points
EFFECT OF SUBSOILER TYPE ON SOYBEAN AND CORN YIELD ON A SILTY CLAY LOAM SOIL

Manitowoc, Wis.
DON’T COUNT ON MOTHER NATURE TO CORRECT COMPACTION
WADSWORTH TRAIL, MINNESOTA

Sharratt et al., 1998
Guidelines for managing compaction:
1. Stay off wet soils
Get the point?
Guidelines for managing compaction:
2. Control traffic – Unload on field edge
Guidelines for managing compaction:
2. Control traffic – No shortcuts
Guidelines for managing compaction:
3. Limit load weight – Practical considerations
Guidelines for managing compaction:
3. Limit load weight – Avoid operations with heavy loads when possible
OTHER KEYS FOR MANAGING SOIL COMPACTION

Evaluate and monitor crops and soil

- Subsoil only if documented compaction conditions exist
- Use common sense
- Address compaction issues
- Factsheet A3367 currently being revised