Causes and Management of Soil Compaction

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Causes of soil compaction

• Machines
  – pressure and weight under tyres
    • pressure dominates effects in topsoil
    • weight dominates effects in subsoil
    • rubber tracks are different

• Livestock
  – high pressure, low weight
    • effects mostly confined to topsoil

- Rule of thumb for tyres
  • pressure (P) at the surface reduces to half its value at a depth equivalent to the width of the tyre

\[
P/2 = \frac{P}{2} = \frac{W}{D} = \frac{W}{W} = 1
\]

\[
D = W
\]

\[
P/2 = \frac{P}{2}
\]
Causes of soil compaction

• Tillage
  – thin bands at tillage depth caused by poorly set or maintained machines, particularly discs
    • magnitude of effect much less than traffic and livestock
  – destabilisation
    • e.g. slumping after rain

• Rainfall impact
  – surface layer, recognised as “crusting”
Dynamics of soil compaction

Effect of increasing weight at same surface pressure

Effect of soil moisture content

From: http://www.extension.umn.edu/agriculture/tillage/soil-compaction/#causes
Tracks

- Lay down area in length rather than width – but pressure not even under this length

Accepted thinking: most stress under tracks is dissipated in the topsoil
Outcomes of soil compaction
And it’s not just cultivated soils!
Wheels have a big impact!

One week later!
Effects of tracking on infiltration

non-trafficked > by average factor of 4

No obvious wheel track in stubble
375 mm/h infiltration

Wheel track evident in stubble
No measurable infiltration
Outcomes of poor infiltration
Compaction makes soils stronger

First video, no-till for 3 years with random traffic

Second video, no-till and no traffic for 3 years
Percentage savings in tillage draught on non-trafficked soil

![Graph showing percentage savings in draught with different depths of tillage.]

Percentage Savings in Draught on Non-Trafficked Soil

- 60% saving at 100 mm depth
- 30% saving at 200 mm depth
- 20% saving at 500 mm depth
Compaction makes soil management more difficult and costly

- Energy to loosen. Energy to re-compact
- Loss of moisture
- Uneven germination and growth
  - Timeliness effects on subsequent chemical applications
  - Poor stale seedbed performance
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Random traffic  Non-trafficked soil
COMPACTION MANAGEMENT
Managing compaction
First principles – try and avoid wet soils

• Maintain existing and consider introducing new drainage schemes
Managing compaction
Choosing and using tyres correctly

• Learn the principles
  – manufacturer’s literature and training workshops
    • tyre data book or pdf
  – lowest inflation pressure for load and speed
Tyres have very different characteristics – but also costs!
Tyre (and wheel) costs for previous slide (each, Jan 2016)

- Agribib 18.4 R34 144A8/141B TL at 1.2 bar
  £820 to carry 2230 kg at up to 50 km/h

- Xeobib VF600/60 R34 149D TL at 0.5 bar
  £1570 (including DW20B x 34 wheel at £420)
  to carry 2245 kg at up to 65 km/h

- Xeobib VF600/60 R30 147D TL at 0.5 bar
  £1320 (including DW20B x 30 wheel at £390)
  to carry 2125 kg at up to 65 km/h
Demonstration of the effects of changing tyres

Combine on standard tyres
The effect of more tyres and lower pressures

Same day, same combine, duals at lower pressure
Tracks

• Advantages
  – Less area tracked on each pass
  – More efficient pulling power
    • 4% compared with 10% slip
  – Less rutting

• Disadvantages
  – Heavier than wheels
  – More expensive than wheels
  – Can do more damage to crops on turning

Figure 1. Maximum power is available at the peak of each curve — a compromise between rolling resistance and wheel slip.
Setting up machinery combinations properly

• Mounted cultivators
  – correct ballasting
  – 3-point hitch geometry
    • top link position should ensure weight transfer onto rear wheels

• Trailed cultivators
  – correct ballasting
  – particularly important with single tracks
Keep an eye on weight

- Take time to remove excess weight

Not always easy

or appropriate

and can remove too much!
The effects of increasing weight

It’s load that does damage at depth

Could this be a reason for the plateau in wheat yields?

Timeline from the 1930s to the present day

Predicted pressure at 0.5 m depth, bar

2.5 t vehicle

21 t vehicle

850 kg Horse

11.2-28

12.4-36

16.9-34

18.4-38

16.9 R 34

710/70 R 38

800/65R32

1050/50R32
Managing compaction

Controlled Traffic Farming - CTF

• any system that confines all tracks to least possible area of permanent traffic lanes
  – CT is NOT prescriptive about tillage
  – CT is NOT just about keeping tramlines in the same place
  – Commitment to continual improvement
Increased crop yields

% increase in yield by crop type under controlled compared with random traffic

Numbers in brackets denote number of research results from which data were taken
CTF – how?

• Match as many track gauges as possible

• Match implement widths

• Introduce a Global Navigation Satellite System (GNSS) with RTK correction
Matching track and implement gauges

“OutTrac” CTF system

Cereal harvesting

Grain auger

Trailer

Chemical application

Harvester e.g. 2.8 m

Other vehicles e.g. 2 m

Cultivator/drill
East Hendred 10 m OutTrac system

20% tracked area
Is there compaction?

Are conditions right or will the wings smear?

Will subsoiling let out too much moisture?

Is it economic to subsoil?

Have we got time?

What depth to subsoil?

East Hendred, Julian Gold

“Once a CTF system is set up farming gets much simpler”
Baling at East Hendred
- dropping or moving bale to the right place

https://www.youtube.com/watch?v=ZMqBBsqKKq4
Matching widths

TwinTrac – tractors straddle harvester passes

Max 6 m wide implements or multiple of

Presentation sponsored by:
Only an RTK GNSS system provides repeatable positioning

GNSS satellites e.g. GPS, GLONASS, Galileo

RTK

Network centres

Base

EPHEMERIS ERRORS
Why CTF?

- Avoids soil damage from traffic on large proportion of field:
  - lower costs
    - less tillage needed
    - implements easier to pull
  - boosts crop yields
    - average increase of around 10%
  - no-till systems work better
    - managed traffic lanes
    - little or no yield loss in early years
  - reduces greenhouse gas emissions
    - nitrous oxide and CO₂
Easier transition between crops

Soil conditions following onion harvest

CTF

Conventional
CTF can allow direct planting of potatoes without tillage after onions for example.
## Lower energy for CTF

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Conventional</th>
<th>CTF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time for crop establishment, h/ha</td>
<td>1.21</td>
<td>0.86</td>
</tr>
<tr>
<td>Fuel needed, l/ha</td>
<td>38</td>
<td>23&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Energy, kWh/ha</td>
<td>71</td>
<td>22</td>
</tr>
</tbody>
</table>

<sup>1</sup>Equivalent to a saving of about £10/ha in fuel costs
Comparison of costs using Farm Management Pocketbook\(^1\)
Clay soil

<table>
<thead>
<tr>
<th>Operation</th>
<th>Traffic, plough</th>
<th>Traffic, min till</th>
<th>CTF, min till</th>
<th>CTF, no-till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsoiling</td>
<td>12</td>
<td>12</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Ploughing</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary cults</td>
<td>45</td>
<td>47</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Drill</td>
<td>26</td>
<td>26</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Roll</td>
<td>15</td>
<td>15</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>168</strong></td>
<td><strong>100</strong></td>
<td><strong>67</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

\(^1\)Nix, 2012.  [www.thepocketbook.co.uk](http://www.thepocketbook.co.uk)
What makes a change to CTF difficult?

- Perceived cost
- Poor compatibility of machines
- Perceived need for extensive tillage
- Uncertainty and risk
- Complication and attention to detail
- An element of inflexibility
- Time and inertia
CTF can turn tracking on its head!

Conventional: 45 – 85% tracked each season
CTF: 70 – 85% permanently not tracked
Join the Smart Agri-Systems Platform for information on soils, precision farming & CTF
SOIL REPAIR AND PROTECTION
Subsoiling

• Consider carefully:
  – before
  – during
  – after
Soil looseners

Chisel tine (Shakerator)

Conventional Subsoiler

High lift Winged Subsoiler

Low lift wings + leading disc

Paraplow

Moleplough
Effect of wings

Draught
- Conventional subsoiler: 20.43 kN
- Winged subsoiler: 26.58 kN

Disturbed area
- Conventional subsoiler: 0.098 m²
- Winged subsoiler: 0.184 m²

Specific resistance
- Conventional subsoiler: 208 kN/m²
- Winged subsoiler: 144 kN/m²

After: Spoor and Godwin, 1978
Get the depth, spacing and angle right

• Depth just below compact layer

• Spacing:
  – 1.5 x depth for simple tine
  – 2.0 x depth for winged tines
  – 2.25 x depth for winged and leading tines

• Angle of share
  – 20 deg to horizontal
Subsoiling can make compaction worse!

As found
After subsoiling
Large tractor
Large + medium tractor
Tracked tractor
TT + medium tractor
Mole ploughing might be a better option

After subsoiling or mole ploughing is a good time to think about controlled traffic farming (CTF)
Loosening maintained with CTF
4 years after subsoiling