Presentation 2
Subsoiling and Soil Management
Dick Godwin
Outline

Effects of structural damage
- Yield
- Tillage
- Runoff/Erosion/Flooding

Assessing structural damage

Repairing structural damage
- Moling and
- Subsoiling

Aftercare
- Controlled traffic
- Lower Ground Pressure

Concluding comments
The assessment explored the total costs of soil degradation:

• The total quantified costs of soil degradation are estimated at between $1.5 bn and $2.0 bn per year.

• **Compaction** and loss of soil organic content account for 39% and 45% respectively of annual costs.

• Silts and sands account 67% of total estimated erosion costs, and clays and sands for 91% of compaction costs.

• Almost 80% of total quantified costs occur offsite.

• In terms of soilscapes, arable farming accounts for over 70% of erosion and compaction related costs.
Relationship between maize silage yield and soil bulk density (Quebec)

Sandy loam soil

Dry matter yield, t/ha

Soil dry density, t/m³

15% at c. $1200/ha* = $180/ha
1.7 t/ha (dm) at $130/t** = $220/ha

* Nix, 39th Edition ** IGER Date??

After: Negi et al, 1981
Relationship between draught force and soil bulk density

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Harper Adams University

Sandy loam soil

250% increase or 60% reduction

After: Godwin, 1974
## Traffic control effects on energy/costs requirements (kWh/ha) (£/ha*)


<table>
<thead>
<tr>
<th></th>
<th>No traffic</th>
<th>Trafficked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shallow plough</td>
<td>13 ($8)</td>
<td>32.5 ($21)</td>
</tr>
<tr>
<td></td>
<td><strong>A 60% reduction</strong></td>
<td></td>
</tr>
<tr>
<td>Harrow</td>
<td>7.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Drill</td>
<td>7.5</td>
<td>30.0</td>
</tr>
<tr>
<td>Roll</td>
<td>7.5</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td><strong>A 70% reduction</strong></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>22 ($15)</td>
<td>71 ($50)</td>
</tr>
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</table>

After: Chamen, 1992
Soil condition can radically affect rate of overland flow and can exacerbate surface water flooding, Richard Smith, EA

Poor soil condition is widespread in South West, Richard Smith, EA

Soil loss – no protection 3-5 t/ha/year - Soil regeneration 1 t/ha/year

Drainage installation 1980 ~ 150,000 ha/year - Now 5,000 ha/year

40,000 homes and 7,000 businesses in Severn region were affected by flooding in June-July 2007
Relationship between compaction and infiltration rate

After: Chyba, 2012
Infiltration ~ soil type

Main factors affecting infiltration
- Soil type
- Vegetation/surface cover
Infiltration ~ surface cover

- Old permanent pasture or heavy mulch
- 4 to 8-year old permanent pasture
- 3 to 4-year old permanent pasture lightly grazed
- Permanent pasture moderately grazed
- Hays
- Permanent pasture heavily grazed
- Strip-cropped or mixed cover
- Weeds or grain
- Clean tilled
- Bare ground
Effect of infiltration rate on runoff
Parrett and Tone Catchment, Dorset/Somerset @ Haselbury Plucknet/Chiselborough

Rainfall and runoff rates (mm h⁻¹)

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td>23rd Dec</td>
<td></td>
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<td>24th Dec</td>
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<tr>
<td>25th Dec</td>
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</table>

\( \hat{q}_{\text{poor}} = \text{Peak runoff (mm h}^{-1}\text{), 1-4 mm/hr} \)

\( \hat{q}_{\text{good}} = \text{Peak runoff (mm h}^{-1}\text{), 4-8 mm/hr} \)

% Reduction in peak flow

25% 23% 21% 19%

After: Godwin and Dresser, 2003
From: Schwab et al., 1993
Assessing soil structure
Root development
Evaluation of structural damage

Profile pit

Penetrometer

Electromagnetic Induction

Conductometer 0.3m and 0.9m ranges
EMI survey data.

(After: Smith, 2001)
Wheels have a big impact!
Comparison of forage chopper harvester and round baler traffic
63.8% and 63.4% respectively
Subsoiling

After: Spoor and Godwin, 1978

Plain tine

Wide point, high lift wing

Narrow point, low lift wing
Soil looseners

Chisel tine (Shakerator)  Conventional Subsoiler  High lift Winged Subsoiler

Low lift wings + leading disc  Paraplow  Moleplough
Soil failure

Herringbone cracks

Horizontal cracks

After: Spoor and Godwin, 1978
Mole plough & Herringbone cracks
Subsoiler Draft Force v. Depth

Subsoiling after rubber tracks at 350mm, 88hp.
Subsoiling after tyres at 450mm, 240hp.

63% Reduction

After: Ansorge and Godwin, 2007
Tractor Implement Matching

Table 5.1. Approximate Wheeled Tractor Capability for operating loosening tines.

<table>
<thead>
<tr>
<th>Tractor size</th>
<th>Capability</th>
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</thead>
<tbody>
<tr>
<td>Engine power, hp/kW</td>
<td>Ballasted weight, tonnes</td>
</tr>
<tr>
<td>150/110</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>250/185</td>
<td>12.50</td>
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<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>350/260</td>
<td>17.50</td>
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</tbody>
</table>

Track-laying tractors, of similar power pull 50% more tines at the same depth or tine depth can be increased by up to 20%.
Double pass system

Godwin and Spoor, 2015
In field evaluation of effective loosening

- Visual evaluation need not be conducted in every field if soil types and conditions are similar.
- The visual assessment of surface level provides a simple guide as to the appropriateness of tine spacing.
- If the surface elevation appears to show distinct heave then tine spacing is too wide.
- An even lifting of the soil surface usually indicates a uniformity of loosening and porosity increase.

Godwin and Spoor, 2015
In field evaluation of effective loosening

The following procedure has been found to be effective:

1. Observe the soil flow and surface level during and after a short test run. Where the whole soil area between adjacent tines lifts uniformly, soil breakout at depth is likely to be fairly complete.

2. Excavate a trench across two tines or more to below their working depth. Facing the direction of implement travel, the disturbed soil can be pulled away from the face with a spade to expose the limits of soil disturbance.

3. Following any adjustments, repeat the run, making surface observations as before. Checks on any new disturbance boundary at depth can be made by pushing a rod or penetrometer into the loosened profile.

4. Use a crow bar or fencing stake to partially take the weight of the leg whilst sliding the tine along the toolbar.

5. This process is repeated until the implement setting appears correct, after which a final trench excavation is made for confirmation of the result.

Godwin and Spoor, 2015
Subsequent traffic can destroy good loosening!

Penetration resistance, MPa

Depth, cm

"As found"

After subsoiling

Large tractor

Large + medium tractor

Tracked tractor

TT + medium tractor

After: Chamen 2011
Issues of aftercare

A single mouldboard ploughing operation, can re-compact the soil to a greater density than before loosening.

To overcome this:-

1. Adopt a single pass system: deep loosening + surface cultivation + drilling where the seed is dribbled down within the working width of the subsoiler.

2. As soil loosening after mouldboard ploughing is not an easy operation use a mouldboard plough fitted with “under-buster” tines.

Other alternatives are to:

1. Reduce the weight and inflation pressure using low ground pressure systems, or

2. Restrict field traffic to pre-determined lanes within the field, controlled traffic.
Random Traffic Problems

Extensive areas of the field are exposed to trafficking

Random Traffic
+ Plough = 85% covered
+ Minimum Tillage = 65% covered
+ Direct Drilling = 45% covered

Wheat, Czech Republic

Potatoes, UK

Kroulik, M., 2012, Sabbatical Study at Harper Adams University,
Lower Ground Pressure:

**Tyres and Rubber Tracks**

+ Simple
+ Cheap
+ Less working time and improved fuel economy, trafficability and manoeuvrability

- Pressure is applied (but lower)

**Extra costs tyres**

Tractor - 280 hp : Ultraflex tyres extra = $1.5/ha

Combine: Ultraflex = $0.75/ha

Price offset by fuel savings (c.20%)

*Personal communication: Mozziconacci, Michelin*

**Extra costs tracks**

Combine: + $5 to $6/ha for 5 - 7 year life

Price offset by improved trafficability, narrower operating widths & operating up and down hills

*Personal communication: Tyrell, Claas UK*
Whole Machine Comparison

30 t

33 t

11 t

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Sub-soil Pressure at 0.3m deep

Controlled Traffic Farming

- Simple concept
- Soil structure
  - Infiltration + 400%
- Crop yields
  - “CTF (+LGP) = +10 to 15% yield”
- Fuel, time and machinery cost savings
  - “70% reduction between trafficked & untrafficked”
- GPS guidance and steering
- Track width and harvester width matching

Source: CTF Europe
Aim: To compare the effects of alternative traffic and tillage systems on crop yield, energy and economics, water holding and infiltration rates over an extended period circa 10 years.

- 3 x 3 Factorial
- 4 blocks
- 9 treatments
- 80m x 4m
- Long term trials
- 10 years+
- Prepared site

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Random High Pressure Traffic</th>
<th>Controlled Traffic</th>
<th>Random Low Pressure Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional</td>
<td>Conventional</td>
<td>Conventional</td>
</tr>
<tr>
<td>Minimum</td>
<td>Minimum</td>
<td>Minimum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Direct drill</td>
<td>Direct drill</td>
<td>Direct drill</td>
<td>Direct drill</td>
</tr>
</tbody>
</table>

No-till had a problem in wheel marks in all traffic systems

Drilled late (November 9th 2012) into wet soil with disc drill

Winter wheat – 29th May 2013

After: Smith, Misiewicz, Chaney, White & Godwin, 2013
Tillage vs Traffic Study
Winter Wheat Yield
Combine harvester results

19% (1.39 t/ha) increase in yield.

10% LSD = 0.6 t/ha

After: Smith et al., 2014
Tillage and Traffic Study
Winter Wheat Yield
Hand Sample Results

Untrafficked yields significantly higher than wheelways (p<0.05)

Untrafficked yields:
- Deep: 8.97 t/ha
- Shallow: 8.10 t/ha
- No-till: 10.72 t/ha

Wheelways yields:
- Deep: 7.69 t/ha
- Shallow: 7.04 t/ha
- No-till: 4.34 t/ha
CTF can make a difference to soil structure

After: Chamen, 2011

Zero traffic for 15 months  2 passes post harvest  3 passes post harvest
Compaction

- Can reduce yield by 10-15%
- Increases tillage energy, time and costs by 200-300%
- Reduces infiltration by and hence increases runoff and flooding

Improved soil and water management is achieved by

- Reducing contact pressure, and
- Reducing traffic intensity
- These costs are small in comparison to the potential economic benefits
- Ensure adequate drainage

Remember prevention is better than cure

- However, if all else fails equipment/techniques are available to alleviate compaction
- But take care on freshly loosened soil as it is vulnerable to re-compaction.
“Man has only a thin layer of soil between him and starvation”.
Anonymous

“The nation that destroys its soils, destroys itself”.
F. D. Roosevelt

“There can be no doubt that a society rooted in the soil is more stable than one rooted in pavements”
Aldo Leopold

“To forget our soil is to forget ourselves”
Ghandi