Ploughing versus reduced tillage

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Plough or Reduce tillage?

• Plough, or not to Plough, that is the question?

Depends

Presentation outlines

1. No till: Advantage and disadvantages
2. Cultivations: Plough versus shallow and deep tillage
3. HGCA Soil Platform project
No Till

- No-till (direct drilling, zero tillage or conservation tillage in the USA and Australia) - sowing directly into the residues of the previous crop without any prior topsoil loosening
- Reduce production costs while maintaining or increasing yields - possible added environmental benefits?
- Farm suitability for no-till influenced by climatic, soil and cropping

Source: B.D. Sloane et al 2011

No Till: Crop Yields

- Annual yields within ±5%, of those after ploughing but greater seasonal variability
- Potential yield-reducing factors include:
  - Poor incorporation of crop residues
  - An increase in grass weeds and volunteers
  - Topsoil compaction, especially when associated with poor drainage

Yields are most variable in the first or second year of no-till
Winter-sown crops yield better than spring-sown crops
No Till: Crop residues

- Usually 30-100% of the surface being covered with crop residues after drilling
- Quantity of crop residues varies with different crops

Can
- Reduce likelihood of soil erosion and run-off
- Affect the drilling operation
- Reduce the evaporation of water from the surface

No Till: Cover crops

- Important role in some no-till systems, particularly where spring cropping is practised
- Immobilise residual soil nitrates present at harvest
- Contribute organic matter to the soil
- Improve soil structure
- Enhance biological activity of the soil
- Suppress weeds
- Legume cover crops add nitrogen to the soil
Soil suitability for no-till

No-till success varies with soil type

• Lower yields with no-till on soils with poor drainage and weak structure, especially for spring-sown barley after wet winters
• Good internal drainage required for reliable success with no-till
• Soils low in organic matter may lack the ability to acquire a stabilised structure

Soil response to no-till

• No-till dramatically changes the soil environment
• Organic matter accumulates near the soil surface
• A stable system of vertically-oriented pores and cracks may develop due to increased earthworm activity and the presence of stable root channels
• The lack of disturbance causes bulk density to increase in the top 25 cm of soil
• Acidity and the content of phosphate may increase near the surface leading to risks of nutrient loss if run-off ever occurs
• Changes in some properties after the introduction of no-till may be within a few months (bulk density, soil strength) or take several years (organic matter)
Weed Control

- No-till can increase grass weeds and volunteer cereals because seeds are retained near the soil surface where they can readily germinate.
- Use rotations and cover crops to reduce weed problems and the dependence on herbicide in no-till systems.
- Widespread adoption of no-till has lead to glyphosate resistance in weeds in Australia and the USA.
- The shading provided by a heavy layer of crop residues with no-till can inhibit germination and early growth of weeds on the soil surface.

After the use of some persistent herbicides there is a need to plough or deep-cultivate to avoid damaging the following crop.

Diseases

- No-till can lead to different disease pressures compared to ploughing since it leads to more crop debris on the surface compared with partial inversion.
- The risk of fusarium, ergot and sclerotinia will be higher under no-till. In contrast, the risk from eyespot will be reduced.
- Where the survivability of volunteer cereals is increased under no-till, these volunteers can act as a ‘green bridge’ from one season to the next for rusts and mildew.
Pests

- Pests can be fewer under no-till conditions because of increased numbers of predators

- Crop residues on the soil surface, particularly in wet conditions, can increase slug populations, causing damage to young seedlings

Environmental effects of no-till

- The lack of soil disturbance and presence of crop residues reduces the likelihood of soil erosion and run-off with loss of particulate P

- There is no clear evidence that no-till influences nitrate leaching

- Earthworm populations are higher under no-till than under ploughing and increase with the duration of no-till
Greenhouse gas emissions and fuel usage

- Emission of the greenhouse gases (GHG) from no-till soils is highly variable
- Carbon sequestration tends not to increase to depth with no-till but it does increase near the surface (0-30cm)
- Higher GHG emissions, particularly N2O, on poorly drained soils, may counterbalance greater carbon sequestration so that no-till may have a negative effect on carbon footprinting
- Fuel consumption under no-till is invariably less than under conventional ploughing
- **Potential fuel savings, on an average fuel consumption of 43 l/ha under a ploughing system, range from 50-80%**

No-till: Summary

- Yield impacts depend on soil type, climate and crop-type
- Residues reduce erosion but can increase disease and slug risk
- Cover crops and rotation management important for weed control
- Soil benefits can take many years to be realised
- Earthworms and natural enemies increased
- Organic matter increased in surface
- Significant savings in fuel use
Cultivations

Ploughing vs shallow/deep tillage

The STAR project
Long-term rotational systems study started in autumn 2005 at Stanaway Farm, Otley, Suffolk on a Beccles/Hanslope Series clay soil. Funded though the Felix Thornley Cobbold Trust and delivered by NIAB TAG

Examines the interaction between four rotations and four cultivation methods

<table>
<thead>
<tr>
<th>Cultivation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a Annual plough</td>
<td>Treatment is ploughed every year</td>
</tr>
<tr>
<td>b Managed approach</td>
<td>Decision on cultivation regime is based around soil/weather conditions, previous cropping, weed burden, soil assessments and local best practice</td>
</tr>
<tr>
<td>c Shallow tillage</td>
<td>Treatment is cultivated to ≈5–10 cm using a non-inversion technique</td>
</tr>
<tr>
<td>d Deep tillage</td>
<td>Treatment is cultivated to ≈20–25 cm using a non-inversion technique</td>
</tr>
</tbody>
</table>

Yield response

Long-term yield responses over project years 1-6

Presented as a percentage of the ploughed treatment within each rotational strategy and averaged across all seasons

<table>
<thead>
<tr>
<th>Relative yield return (relative to ploughed approach)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Plough</td>
</tr>
<tr>
<td>Managed</td>
</tr>
<tr>
<td>Shallow</td>
</tr>
<tr>
<td>Deep</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>
Margin response

Long-term cumulative margin responses over project years 1 - 6

Cumulative gross margin minus machinery cost (£/ha)

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Spring</th>
<th>Cont</th>
<th>Alt</th>
<th>Fallow</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plough</td>
<td>3825</td>
<td>2164</td>
<td>2246</td>
<td>1637</td>
<td>2468</td>
<td></td>
</tr>
<tr>
<td>Managed</td>
<td>3816</td>
<td>2438</td>
<td>2707</td>
<td>1410</td>
<td>2593</td>
<td></td>
</tr>
<tr>
<td>Shallow</td>
<td>3224</td>
<td>2139</td>
<td>2548</td>
<td>1635</td>
<td>2387</td>
<td></td>
</tr>
<tr>
<td>Deep</td>
<td>4168</td>
<td>2316</td>
<td>2223</td>
<td>1641</td>
<td>2587</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3758</td>
<td>2264</td>
<td>2431</td>
<td>1581</td>
<td></td>
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</tr>
</tbody>
</table>

Cumulative margin accumulation

Plough  Managed  Shallow  Deep
Soil penetration resistance in relation to cultivation approach

HGCA Soil Platform Project

- To assess differences in soil conditions for plant growth at 3 sites that have been in place for 10 (JHI), 9 and 6 (NIAB TAG) years
- To quantify carbon concentrations under different forms of soil management
- To measure the impact of soil management on the performance of contrasting cereal varieties
- To determine broader impacts of major changes in soil management practices to more ‘sustainable’ systems
- To measure inputs and outputs of production system costs to quantify farm gate impacts of major shifts in soil management practices
- To deliver a combination of in-depth quantitative analysis and practical tools to advisors and the farming community to define favourable soil physical conditions for cereal production
Measures to assess soil physical status

What are the conditions for crop growth as affected by soil management?

- Least Limiting Water Range (aeration, hardness and water)
- Water stable aggregation (<0.25mm associated with plant and microbial exudates while <2mm associated with roots and hyphae)
- Resistance and Resilience [Compression (vehicle traffic) and Slumping (weathering)]
- Plant available water (field capacity, wilting point and Pore size distribution, air-filled porosity)
Example

Project outcomes

Detailed analysis across 4 field experiments of:

- Impacts of reduced tillage on crop productivity and GAEC relevant soil properties
- Economic analysis of costs/benefits for farmers
- Identification of favourable cereal variety traits for reduced tillage systems
- Information on rotation impacts to productivity
- Measurement of soil health for crop production in relation to different soil management option
- KE through demonstration farms and strong communications programme
Summary

- Drier and more stable soils are most suited to no-till. No-till is not an easy option. It demands commitment, time and patience. Assessing the experience of others and visiting other farmers will be beneficial.

- Findings from the STAR project suggest that while ploughing tends to give the highest yields the margins can be improved with a managed approach.

- Detailed soil physical analysis of the long-term experiments in the platform project will allow us to understand the impacts of various tillage options on crop productivity, soil properties and economic costs and benefits for farmers.

Thank you