(Callum Weir)

Reduced tillage - Non-inversion and shallow cultivation in organic systems (United Kingdom)

Non-inversion and shallow cultivation in organic systems

DESCRIPTION

Non-inversion and 'shallow' ploughing cultivation strategies on an organic farm, where the use of herbicides for weed control is prohibited.

The shallow plough is used on land dominated by clay soils at an organically farmed estate, south of Cambridgeshire, UK. Previously, 'conventional' ploughs were used, which plough deeper than a shallow plough. However, ploughing deeper would often bring large chunks of raw clay from the subsoil to the surface. This would quickly solidify, locally referred as when the soil turns to 'concrete'. Numerous cultivations were then required to reduce these 'concrete' soil chunks into a seed bed. It was a laborious, expensive task which sacrificed soil health to produce a less than satisfactory result. However, the farm still required a plough of some form as a means of weed control through inversion. As it is an organic estate, chemical sprays could not be used. A shallow plough was invested in as a way of striking the balance between overcoming the problems of creating a seedbed, but also maintaining the weed control benefits of inversion tillage. It has been very successful in reducing the input requirements, and at the same time increasing the quality of the output. Whilst shallow ploughing has challenges, such as full inversion of weeds in very dry conditions, on balance it is much better for the farming business than the previous alternative. We are able to do less damage to soil, and increase outputs which is important due to agricultural labour scarcity and smaller weather windows due to climate change.

Reduced tillage options have been a challenge to combat in organic systems where herbicides are prohibited. As such, trials of reduced tillage options have been explored. These include; 1)Non-inversion tillage where no ploughing is done and soil is cultivated to the first 100 mm. 2)Shallow ploughing where a specifically designed plough inverts soil to a depth of 125 mm, as opposed to traditional plough depths of 200 mm.

The purpose of this technology is to minimise soil disturbance to enhance the soil structure, biology and chemistry, whilst creating a seed bed and controlling weeds. The challenge on the specific site is there has been a history of annual plough, which has led to the proliferation of weeds that thrive on such systems. These include creeping thistle and common docks. As such, there was also the purpose of 'disrupting' the existing system in order to control these weeds. The only specific input required was a shallow plough, designed to invert soil from lower depths. For non-inversion tillage, a subsoiler and disc cultivator were used. The non-inversion tillage was done at two sites; one cereal stubble and one out of a fertility building two-year grass and clover ley.

Benefits/impacts/things land owners did/did not like:
Non-inversion tillage:
-Instead of ploughing, non-inversion tillage from the fertility ley allowed us to keep the soil structure from 2 years of grass/clover intact and in the right soil profile. We weren't burying the friable, high-nutrient and porous top soil 200 mm under the ground and we weren't lifting heavy, lower-aerobic soil to the surface where we wanted to plant.
-This meant that plants established quicker and we were able to drill later, despite the fields being very heavy, poorly drained fields.
-Weeds were killed, primarily through timely cultivations during a hot-spell, so that the cultivator brought roots to the surface to dry them.
-Drainage was evident after drilling as we were able to graze sheep on the wheat in March.
-Crops have tillered well and responded to nutrients.
-Establishment costs were approximately £30/ha cheaper.
-However, non-inversion tillage in cereal stubbles has not been as successful due to weed control, and whether the cheaper costs outweighs the weed burden remains to be assessed. The reason for this is not being able to cultivate during the hot weather (as this came before harvest).

LOCATION

Location: Wimpole Estate, United Kingdom

No. of Technology sites analysed: single site

Geo-reference of selected sites
- -0.04205, 52.14849
- -0.04205, 52.14849

Spread of the Technology: evenly spread over an area (4.0 km²)

In a permanently protected area?: Nee

Date of implementation: 2018; less than 10 years ago (recently)

Type of introduction
- ☑ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☐ during experiments/ research
- ☐ through projects/ external interventions

-In addition, in cereal stubbles, we have seen less creeping thistles and docks, but more wild oats and cereal volunteers.

Shallow ploughing:
-Cheaper establishment costs through lower diesel usage (yet to be quantified).
-Better in many circumstances of inverting soil completely, but from a much lower depth.
-Did not bring up any large clumps of sub-soil which the conventional plough would. These result in much cultivations to break the clumps down.
-Ploughing 'on-land' meant that there was no smearing in the furrow from tyres.
-Lower HP requirement – 180 hp tractor ploughing 3.2 m to 125 mm on heavy land.
-Ploughing left over-winter did not require more than one cultivation before drilling as ploughed soil was friable from lower plough depth.
-That being said, there were favourable ploughing conditions in 2018. Regardless, we have sold our conventional plough because we like the shallow plough so much.

General benefits are:
-Reduced, prevented or restored land degradation
-Improved/preserved biodiversity
-Increased adaptation/resilience to climate change/extremes and its impacts
-A potential beneficial economic impact

The compilation of this SLM is a part of the European Interreg project FABulous Farmers which aims to reduce the reliance on external inputs by encouraging the use of methods and interventions that increase the farm's Functional AgroBiodiversity (FAB). Visit www.fabulousfarmers.eu and www.nweurope.eu/Fabulous-Farmers for more information.

Shallow ploughing green stubbles. (Callum Weir)

Claas Arion tractor ploughing (Callum Weir)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- [ ] improve production
- [x] reduce, prevent, restore land degradation
- [ ] conserve ecosystem
- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [x] preserve/ improve biodiversity
- [ ] reduce risk of disasters
- [x] adapt to climate change/ extremes and its impacts
- [x] mitigate climate change and its impacts
- [x] create beneficial economic impact
- [ ] create beneficial social impact

Land use

Land use mixed within the same land unit: Nee

Cropland

- Annual cropping: cereals - other, fodder crops - clover, fodder crops - grasses

Number of growing seasons per year: 1
Is intercropping practiced? Ja
Is crop rotation practiced? Nee

Water supply

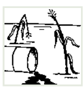
- [x] rainfed
- [ ] mixed rainfed-irrigated
- [ ] full irrigation

Purpose related to land degradation

- [x] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

soil erosion by wind - Et: loss of topsoil



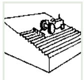
chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

biological degradation - Bs: quality and species composition/ diversity decline, Bp: increase of pests/ diseases, loss of predators

water degradation - Hs: change in quantity of surface water, Hg: change in groundwater/aquifer level, Hq: decline of groundwater quality, Hw: reduction of the buffering capacity of wetland areas

SLM group
- minimal soil disturbance
- integrated soil fertility management
- water diversion and drainage

SLM measures


agronomic measures - A3: Soil surface treatment (A 3.2: Reduced tillage (> 30% soil cover)), A5: Seed management, improved varieties

TECHNICAL DRAWING

Technical specifications

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs
- Costs are calculated: per Technology area (size and area unit: **4 ha**; conversion factor to one hectare: **1 ha = Approx. £45/ha – about 25% less than 'deep ploughing'**)
- Currency used for cost calculation: **GBP**
- Exchange rate (to USD): 1 USD = 0.82 GBP
- Average wage cost of hired labour per day: £90

Most important factors affecting the costs
Most important factors affecting cost are decreased time spent ploughing and lower diesel cost, reducing establishment costs by £15 per ha.

Establishment activities
1. Use of shallow plough (Timing/ frequency: After harvest)

Establishment inputs and costs (per 4 ha)

Specify input	Unit	Quantity	Costs per Unit (GBP)	Total costs per input (GBP)	% of costs borne by land users
Labour					
Person per day	person day	1.0	90.0	90.0	100.0
Equipment					
Ovlac Shallow Plough (7+1f) (one off)	1	1.0	11000.0	11000.0	100.0
Tractor	per day	1.0	180.0	180.0	100.0
Other					
Diesel (120 litres per day)	ltrs per day	1.0	60.0	60.0	100.0
Total costs for establishment of the Technology				**11'330.0**	
Total costs for establishment of the Technology in USD				*13'817.07*	

Maintenance activities
1. Grease plough (Timing/ frequency: once per week)
2. change plough points (Timing/ frequency: once per season)

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [x] 501-750 mm
- [ ] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [ ] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone
- [ ] humid
- [x] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate
Highest rainfall month is August, which is important as this is when cultivations need to occur. As non-inversion and shallow ploughing are faster operations, this means that cultivations can occur at more optimum times.

Slope
- [ ] flat (0-2%)
- [x] gentle (3-5%)
- [ ] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [x] plateau/plains
- [ ] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [x] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in
- [ ] convex situations
- [ ] concave situations
- [x] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [x] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [ ] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [x] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [ ] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [x] fine/ heavy (clay)

Topsoil organic matter content
- [x] high (>3%)
- [ ] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [x] < 5 m
- [ ] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [ ] good
- [x] medium
- [ ] poor/ none

Water quality (untreated)
- [ ] good drinking water
- [ ] poor drinking water (treatment required)
- [ ] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to: both ground and surface water

Is salinity a problem?
- [ ] Ja
- [x] Nee

Occurrence of flooding
- [ ] Ja
- [x] Nee

Species diversity
- [x] high
- [ ] medium
- [ ] low

Habitat diversity
- [x] high
- [ ] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [ ] mixed (subsistence/ commercial)
- [x] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [x] individual/ household
- [ ] groups/ community
- [ ] cooperative
- [ ] employee (company, government)

Gender
- [ ] women
- [x] men

Age
- [ ] children
- [ ] youth
- [x] middle-aged
- [x] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [ ] 50-100 ha
- [x] 100-500 ha
- [x] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [x] medium-scale
- [ ] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [x] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [x] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [ ] individual

Access to services and infrastructure

health	poor			✓	good
education	poor			✓	good
technical assistance	poor			✓	good
employment (e.g. off-farm)	poor			✓	good
markets	poor			✓	good
energy	poor			✓	good
roads and transport	poor			✓	good
drinking water and sanitation	poor			✓	good
financial services	poor			✓	good

IMPACTS

Socio-economic impacts

Crop production	decreased					✓			increased	
crop quality	decreased					✓			increased	
fodder production	decreased							✓	increased	Crop quality before SLM not able to handle grazing, but now can graze so large increase in fodder/animal production compared to previous model
animal production	decreased							✓	increased	Crop quality before SLM not able to handle grazing, but now can graze so large increase in fodder/animal production compared to previous model
land management	hindered					✓			simplified	
expenses on agricultural inputs	increased					✓			decreased	
farm income	decreased					✓			increased	
diversity of income sources	decreased					✓			increased	
workload	increased					✓			decreased	
work/life balance	None						✓		None	

Socio-cultural impacts

recreational opportunities	reduced					✓			improved	
SLM/ land degradation knowledge	reduced					✓			improved	

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)	reduced						✓		improved	
surface runoff	increased						✓		decreased	
excess water drainage	reduced						✓		improved	
soil moisture	decreased						✓		increased	
soil cover	reduced					✓			improved	
soil loss	increased						✓		decreased	
soil crusting/ sealing	increased							✓	reduced	
soil compaction	increased						✓		reduced	
nutrient cycling/ recharge	decreased					✓			increased	
soil organic matter/ below ground C	decreased						✓		increased	
vegetation cover	decreased					✓			increased	
biomass/ above ground C	decreased					✓			increased	
invasive alien species	increased					✓			reduced	
animal diversity	decreased					✓			increased	
beneficial species (predators, earthworms, pollinators)	decreased					✓			increased	
pest/ disease control	decreased			✓					increased	A small decrease in disease control with shallow ploughing is not as effective as inverting with a conventional plough. This is because less of the stubble from the previous crop would be inverted, creating a greater chance of disease carryover, for example Septoria nodorum blotch.
flood impacts	increased					✓			decreased	
drought impacts	increased					✓			decreased	

Off-site impacts

reliable and stable stream flows in dry season (incl. low flows)	reduced					✓			increased
downstream flooding (undesired)	increased					✓			reduced
downstream siltation	increased					✓			decreased
groundwater/ river pollution	increased					✓			reduced
buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced					✓			improved
wind transported sediments	increased					✓			reduced
impact of greenhouse gases	increased					✓			reduced

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative					✓			very positive
Long-term returns	very negative						✓		very positive

Benefits compared with maintenance costs

Short-term returns	very negative				✓				very positive
Long-term returns	very negative					✓			very positive

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all				✓		very well	
seasonal temperature increase	not well at all				✓		very well	Season: spring
annual rainfall decrease	not well at all			✓			very well	
seasonal rainfall decrease	not well at all				✓		very well	Season: spring

Climate-related extremes (disasters)

local rainstorm	not well at all			✓			very well
local thunderstorm	not well at all			✓			very well
heatwave	not well at all			✓			very well
drought	not well at all			✓			very well

Other climate-related consequences

extended growing period	not well at all				✓		very well
reduced growing period	not well at all				✓		very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [x] single cases/ experimental

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [ ] 0-10%

- [ ] 1-10%
- [ ] 11-50%
- [ ] > 50%

- [ ] 11-50%
- [x] 51-90%
- [ ] 91-100%

Has the Technology been modified recently to adapt to changing conditions?
- [ ] Ja
- [x] Nee

To which changing conditions?
- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view
- Cheaper establishment costs and quicker establishment time mean it will benefit the farm in the long term as labour becomes an issue (regardless of Brexit).
- Makes soil more resilient to changing weather conditions, both drier and wetter conditions.
- Reduced soil carbon emissions and diesel emissions from tractor.
- Better soil structure, biology and chemistry to boost yield, plus allows us to use plough sparingly as a 'reset' button when we really need to.
- However, there is a risk to yield if not used correctly. Plus, we may solve one weed issue (thistles and docks) and move to another weed issue (cereal volunteers, blackgrass and wild oats).

Strengths: compiler's or other key resource person's view

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome
- We may solve one weed issue (thistles and docks) and move to another weed issue (cereal volunteers, blackgrass and wild oats). - Use dry June/July to non-invert fertility leys, allowing plough to be used as a reset button later in the rotation.
  - Minimise non-inversion in cereal stubbles to cleanest crops.
- Management demand to adapt technology to annual changes in conditions (not as easy as ploughing or spraying in any conditions – to do this, you must be adaptable). -Operator education -Planning

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

REFERENCES

Compiler
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Resource persons
Callum Weir - land user

Full description in the WOCAT database
https://qcat.wocat.net/af/wocat/technologies/view/technologies_5012/

Linked SLM data
n.a.

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