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Reduced tillage in organic farming

Lessons from the TILMAN-ORG project and beyond

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ABSTRACT

Reduced tillage can lead to improvements in soil health and enhance ecosystem services including carbon sequestration, reducing soil erosion, improving soil fertility and biodiversity, whilst reducing CO_2 and N_2O emissions from soils and decreasing energy usage. However, some consider it incompatible with organic farming stemming from concerns around weed control, nutrient availability, and ley incorporation, as well as insufficient equipment and knowledge to make the system work. ORC took part in the "Reduced tillage and green manures for sustainable organic cropping systems – TILMAN-ORG" project where these issues were investigated.

The results of this project showed that organic farmers can consider reduced tillage through a pragmatic site-specific approach: they can strategically employ occasional shallow inversion tillage or even shallow non-inversion tillage to realise some of the benefits of reduced tillage without significant yield loss. Specifically, the field trials conducted by ORC showed shifts in the weed communities, improvements in crop establishment and only moderate effects on crop yield over three cropping cycles.

Figure 1 Field preparation with the Ecodyn (left) and with ploughing (right) in the trial at Duchy Home Farm

Further research and development needs that were identified related to synchronisation of nutrient supply and demand, machinery improvements and adaptation of farm-specific reduced tillage systems to keep weeds controlled in the long-term. ORC is currently exploring combining reduced tillage with green manures, to improve nitrogen provision and weed control as a promising option for UK arable cropping systems. Adopting living mulches, i.e., cover crops grown simultaneously with the main cash crop, can potentially enable further reductions in tillage, or even organic no-till systems.

INTRODUCTION

Organic farming can improve carbon sequestration thanks to its use of fertility building leys, diverse crop rotations and organic manures and compost[1]. However, these benefits risk to be offset by ploughing, that can undermine soil health via compaction and disruption of the microbiome of the soil and can generate excessive mineralisation of organic matter. Reducing tillage can be achieved in many ways, including shallower cultivation and less frequent soil disturbance. Adopting these approaches can reduce energy consumption and help offset greenhouse gas emissions through carbon sequestration[2], whilst improving soil fertility and enhancing microbial and earthworm communities[3].

However, alternatives to ploughing are especially problematic in organic farming[4,5]. The main risk is that, by reducing tillage and by excluding inversion tillage, it can be difficult to control weeds and ensure plant nutrition in the absence of herbicides and mineral fertilisers. In addition, destruction of the ley, an element so integral to an organic rotation for soil fertility, becomes a huge practical challenge without ploughing. Machinery is available to help address these challenges and new systems are being trialled to investigate whether UK organic farming and reduced, or even no-till, can coexist or whether system changes can be found to integrate the benefits of organic agriculture and reduced tillage approaches.

REDUCED TILLAGE EXPERIMENT

As part of the TILMAN-ORG European project, we investigated the use of the Ecodyn combination drill and cultivator, to assess its potential for UK organic farming. Field trials were run at Duchy Home Farm (Tetbury, Gloucestershire) between 2010 and 2013, comparing shallow non-inversion tillage based on the Ecodyn machine to a depth of 7.5 cm with a more typical inversion tillage using a mouldboard plough to a depth of 15 cm.

In all three years, crop establishment was significantly more successful in the reduced tillage system however weed cover was also higher (**Figure 2**). The advantage of the reduced tillage was particularly apparent during dry spring sowing conditions, where the lack of inversion is likely to have helped conserve soil moisture and retention of soil organic matter in the upper soil layers and may have conferred a greater water holding capacity. However, the Ecodyn machine performance was weakened under wet conditions, as the duckfeet shares became clogged with soil. Consequently, the adoption of reduced tillage implies a certain degree of technical challenge, often requiring modifications to make the machinery suitable for specific soil conditions.

Shifts in weed community composition were observed, with some weed species more prevalent in either the ploughed or the reduced tillage systems, but these are not necessarily linked to increased crop-weed competition from reduced tillage[6].
Average grain yields were similar between the two systems for spring crops (oats and barley) but were 50 % lower in the reduced tillage compared to the ploughed system for winter rye in 2012. Reduced tillage improved soil physical properties, earthworm abundance and community composition. In addition, fuel use was reduced by a third and tillage operations could be completed in a quarter of the time compared to the plough, meaning energy efficiency and profit margins were greater.

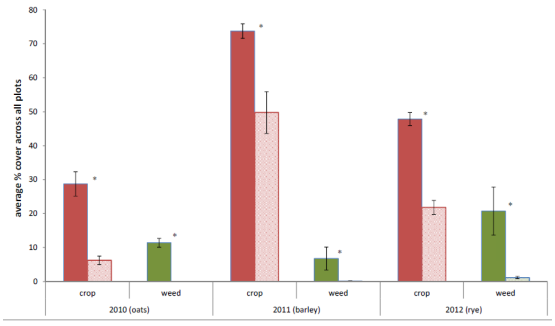

Figure 2 Mean crop and weed cover after establishment in the reduced tillage (solid fill bars) and in the ploughed (shaded fill) systems

In our 40th Anniversary year ORC is helping farmers explore reduced tillage further via an Innovative Farmers field lab investigating a living mulch system where the cash crops in the rotation are intercropped with a (semi-)permanent forage legume. Once the perennial forage legume is established, the main crop can be established by either direct drilling or strip tillage thus eliminating or reducing the need for tillage. The system may require the development of in-crop mulch management devices such as an inter-row mower to reduce competition from the mulch, help control weeds and mobilise nitrogen for the cash crop. The mulch can also be mown and grazed at certain times to reduce its impact on the crop.

CONCLUSION

Unlike common perception, reducing soil disturbance in organic farming through non-inversion tillage is a very realistic option for maintaining crop yields whilst building soil carbon[7]. Combining reduced tillage with green manures is a promising option in the UK to guarantee nitrogen provision and control of weeds. Whilst shallow non-inversion is, at present, the most viable option for limiting the negative impacts of tillage in organic farming, current participatory research into living mulch systems combining zero-tillage and green manures is expected to provide interesting alternative options.

Figure 3 The Ecodyn combination drill and cultivator

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ORGANIC RESEARCH CENTRE 40th anniversary

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