Where less is more

A 10-year study confirms that doing little and treading lightly pays dividends when it to comes to soil productivity. *CPM* speaks to the researcher behind the work.

By Mike Saull

Results from Harper Adams University's long-term traffic and tillage research project have been revealed, confirming that major improvements in soil condition have been achieved from utilising reduced trafficking and tillage.

Fast becoming the Shropshire university's equivalent of the Broadbalk soil fertility experiment at Rothamsted Research, the 'Traffic and Tillage' study was established in 2011 (see box). Now, researchers have compiled the results into a guide to reducing soil compaction having observed the cumulative effects of steel and rubber on the site's sandy loam soil.

The project – led by Dr Paula Misiewicz, a senior lecturer in soil and water management who's been involved in the work for more than ten years – has been funded by The Morley Agricultural Foundation and Douglas Bomford Trust with in-kind support from Väderstad, Michelin, AGCO and Harper Adams University.

It confirms the effects that both traffic management and tillage systems can have on crop yield and farm economy, together with soil biology and health.

In general, the work has found that keeping off the soil and spreading the weight of kit to carry-out any field operations, combined with reduced tillage, have provided the best, long-term yields and gross margins. This goes hand-in-hand with building and maintaining a healthy soil environment – one that encourages good rooting and remains stable.

According to Paula, the sandy loam soil chosen for the experiment is quite commonplace in an arable situation, with its lack of clay rendering it more susceptible to compaction and slumping when worked and trafficked.

"Because we're based in the wetter west of England, it's trickier to work

Yield versus structure
Shallow tillage proved the best compromise between yield and soil structure, says Dr Paula Misiewicz.

or drill at optimum soil moistures, increasing risks particularly under direct drilling where the soil hasn't been loosened and allowed to dry out."

Using X-ray computed tomography to scan the soil across the treatments confirmed the difficulties with compaction, although keeping traffic off the plots, particularly on soils that had been loosened, helped to maintain its structure and porosity.

In contrast, using standard tyre pressures and travelling across ground that's been deeply loosened resulted in re-compaction, so on these soils it pays to tread lightly, she says. However, under a reduced cultivation practice – in this case operating to just 10cm depth – soils are more resilient and less liable to slumping back down when travelled across.

Deeper tillage reduced the number of earthworms compared with the other two cultivation systems, which also has a negative effect on long-term porosity and drainage.

Trafficking also had an effect on soil porosity, adds Paula. "Standard practice trafficking across the soil halved pore space in the experiment, compared with where the soil wasn't run across in the controlled traffic system plots.

"These effects on compaction are almost certainly linked to different levels of soil organic carbon across the treatments – a component of soil organic matter which helps to bind the soil more strongly, giving it more resilience, as well as improving nutrient storability."

The highest soil organic carbon stocks in the topsoil were found in the controlled traffic farming (CTF) zero tillage plots with an average of almost 70t/ha compared with closer to 60t/ha where the soil had been tilled and trafficked. "This confirms that leaving soil alone helps to reduce carbon losses and build natural fertility," says Paula.

Perhaps unsurprisingly, zero tillage created the greatest problems when establishing crops, and the greater the level of trafficking in this system, the poorer the plant count still. In spring oats, for example, running across the soil cut plant numbers by 28% compared with a controlled traffic system.

Shallow tillage – which creates a looser seedbed – provided the most favourable soil conditions for establishment, particularly on soils that had previously been compacted by trafficking.

Compaction also affected root development, particularly in the more sensitive bean crop compared with cereals. This was shown by crops grown in the controlled traffic plots which had a much greater root biomass, commonly well above double that where soils had been run across with kit using standard tyre pressures, and around 30% more than the crops established under a low-pressure tyre system.

Paula says during the years, deep tillage generally offered no yield advantage over shallow tillage; shallow tillage giving the best compromise between yield and soil structure. Zero tillage, in contrast, resulted in a yield penalty from year one, taking around five years for yields to recover as the soil gradually restructured itself season by season.

However, taking into account the typical time and cost to produce these yields in a farm situation, the less intensive, 'diesel-conserving', controlled traffic system fared well.

"The effects of keeping traffic off the three different cultivation treatments gave yield benefits from the first year and were consistent over time, with controlled trafficking giving a 4% average yield increase across all tillage systems," explains Paula.

Taking into account the different

Establishment method

Plots for the experiment were established using a one-pass Väderstad Topdown multipurpose cultivator.

Traffic and tillage project protocol

The trial set-up at Harper Adams University

The long-term study at Harper Adams University was set up on a 9.5ha field to examine the effects of three alternative traffic management systems: conventional (STP), low ground pressure (LGP) and controlled traffic farming (CTF) for a range of arable crops.

These were established with either a one-pass tillage train operated at deep (250mm) and shallow (100mm depth) cultivation or with zero/no-till.

More than 10 crops have now been grown in a largely wheat-barley cereal rotation with break crops including spring oats, winter beans and most recently millet.

The initial investigation focused on the physical condition of the soil, crop yield and the cost/benefits of the effect of the three traffic management systems managed with the three tillage treatments. More recently it's also included soil biology and health condition including soil carbon stocks.

Experimental plots 80m long x 4m wide were chosen to match the constraints of the machinery available. With nominal tyre widths of 0.6m and 4m wide machines, this resulted in a trafficked area for the CTF plots of 30% of the total area (CTF30%). To mimic commercial practice, results were also considered for a wider CTF system with a trafficked area of 15% (CTF15%).

A Massey Ferguson 8480 tractor with a mass of 12.55t and track gauge of 2.1m was used to apply the traffic and tillage treatments, as well as crop sowing operations each year. The tractor was equipped with Michelin Ultraflex technology Axiobib IF tyres at pressures as low as 10psi.

Tillage cultivation, drilling and combining were all carried out using 4m-wide kit to facilitate CTF systems using a Väderstad Topdown multipurpose cultivator a Väderstad Spirit pneumatic seed drill.

costs and calculating gross margins, the study showed that while the loss in yield from zero tillage in the early years was equivalent to £67/ha (5.5%). Compared with the other cultivation systems, zero tillage reduced costs by £56/ha compared with shallow tillage, and despite initial yield losses was considerably more profitable than deep tillage.

The research firmly confirms that the investment in, and use of, low ground pressure tyres makes sense, believes Paula. She adds that across deep tilled soils there was on average a 5% yield advantage when the low-pressure kit was used, and in the best year, an 11% benefit.

"Assessing the different cultivation systems during the ten years, there's certainly no advantage in deep cultivation, unless soil compaction at depth requires correcting," she comments. "Shallow tillage works well and didn't result in an initial yield penalty, so may be the best option on soils such as those in the experiment that do require regular loosening in the top 10cm or so.

"However, from a soils point of view, a zero tilled soil is visually beautifully structured, with better aggregate stability and more earthworms. So despite the initial yield depression, it's a great approach once the soil is stable."

However, Paula is quick to comment that this gross margin analysis doesn't factor in the additional set up costs to buy and match kit, particularly when using controlled trafficking methods. "This takes considerable planning and investment, but there are farmers who have adopted controlled traffic farming systems to good effect and swear by them."

So what next? The researchers aim to further determine why and how more carbon is stored under some treatments than others. To this effect, one of Paula's PhD students Ana Prada Barrio has grown millet, a C4 plant, in soils where only C3 plants have grown previously.

Measuring the natural abundance of 12C/13C stable isotopes will allow the team to trace the flow of carbon from the C4 crop into the different levels of organic matter. This should provide insights into the mechanisms that determine the residence time of carbon in soils and how they're affected by traffic and tillage treatments over time.

Results derived from these experiments will inform the development of management practices for increasing soil carbon storage to improve soil health, and therefore longer term soil resilience and climate change adaptation. ●

Research findings

The 'Traffic and Tillage' trial site has helped to confirm that leaving soil alone helps to reduce carbon losses and build natural fertility.