Dr Julia Cooper and **Anne Liddon**

explore research on whether organic farmers can reduce tillage while minimising losses in production

Reduced tillage

Evidence of active soil life and good soil structure in a conventionally managed no-till field in Lincolnshire

Reduced tillage is promoted by the UN Food and Agriculture Organization as a key means to improve sustainability and make more efficient use of natural resources, particularly where soils are fragile and prone to degradation.

But concerns about nutrient supply, soil structure and weeds have meant that uptake in the organic sector has been slow in most European countries. Researchers from the TILMAN-ORG project therefore set out to investigate the possibilities for reducing tillage in organic systems while minimising production losses.

The project considered published and unpublished research comparing deep or shallow – that is, less than 25cm – inversion tillage, in which the soil surface and any residues are completely buried, usually with a mouldboard plough, with various categories of reduced tillage under organic systems, in terms of crop yields, weeds and soil carbon. The aim was to identify optimal practices to ensure maximum yield and carbon stocks while discouraging weeds.

Yields

Perhaps the most significant findings for organic farmers were that, although weeds do flourish more readily with reduced tillage – in general there is an increase of 50% across systems – this does not necessarily result in reduced yield.

Across the different systems, reducing tillage intensity cut yields by an average of 7.6% compared with deep inversion tillage. Adopting shallow non-inversion tillage – which is less than 10cm deep – instead of deep mouldboard ploughing had the lowest impact on yields, with reductions being insignificant, but deeper non-inversion tillage up to 25cm down resulted in the largest yield reduction. Shallower inversion tillage, at less than 25cm deep, also resulted in minimal yield reductions at only 5.5%, with significantly higher soil carbon and better weed control, and this may be the best option for organic farmers wanting to improve soil while minimising the impact on yield.

There seems to be no benefit, however, to double-layer ploughing – that is, surface soil inversion and deep soil loosening in one pass – which resulted in yields, weed incidence and soil carbon stocks similar to those of the shallow inversion treatments.

Reduced tillage concentrates weed seeds in surface soils, allowing readier germination and emergence. Organic farmers who traditionally used deep tillage to control weeds need to develop alternative approaches to implement minimum till successfully. In Europe and North America, innovative farmers and researchers are designing systems that rely on well-planned and diversified crop rotations, including cover crops to suppress weeds. These systems use mechanical methods of cover crop destruction such as roller crimpers or sickle bar mowers and no till-drilling equipment. In some cases, a preceding cover crop of rye can almost completely eliminate weeds in a subsequent crop. These systems can be effective for annual weeds, but control of perennials remains challenging.

Combinable crops

Different crops may vary in how appropriate they are for reduced till cultivation. In the study, combinable crops such as wheat and maize suffered the greatest reductions in yield, and this was particularly pronounced under deep non-inversion tillage, with a 13.5% drop in yield.

Cereal yields may be limited by previous crop residues that make it difficult to establish the new crop and also create a potential disease reservoir. Yield reduction for non-combinable crops – potatoes and carrots were considered in this study – was only 6%, but the practices are different. While depth of tillage may be

Drilling barley in the minimum-till plots in Newcastle University's long-term organic versus conventional cropping systems trial

shallower at primary tillage stage, there are several subsequent operations, including roto-tilling before planting and ridging as many as three times during growth. These could result in conditions that reduce weed incidence and minimise yield reduction.

Tillage does, of course, perform functions beyond weed control in organic farming. It may be used to incorporate organic residues, green manures and herbal leys to enable more rapid mineralisation and make nutrients accessible to the crop. It may also help to reduce soil-borne pests and pathogen loads. Implementing reduced tillage may be more challenging than in conventional production because of delayed and limited mineralisation of nutrients from organic matter and lack of synthetic fertilisers.

Strategic tillage

In both conventional and organic systems, the use of "strategic tillage" at critical stages in the rotation may provide an effective strategy to manage pernicious weeds and residue-borne crop disease, but it does need to be balanced against potential negative impacts on soil quality and structure. Any tillage may redistribute carbon gains to greater depths and disturb the biopores formed by roots and earthworms, potentially negating any gains. Temporary shallow inversion tillage may be a good compromise as there do seem to be carbon gains in this system compared to deep inversion ploughing, with improved weed control. By confining any ploughing to dry periods, in which vertically burrowing earthworms work their way into the subsoil, the negative effects may be further reduced.

In conventional farming, reduced tillage's impact on crop yields can vary according to climate, rotation and soil type, but researchers found a trend towards lower yields when either deep or shallow non-inversion tillage was used on light soils, possibly reflecting the difficulty of building good soil structure. Light, sandy soils lack the fine particles that are necessary to form organo-mineral complexes and are also significantly lower in earthworm populations. Without regular tillage, such soils can slump and become more compacted than loamy or clayey soils.

Carbon stocks are of particular interest in the context of ecosystem service provision. Research on carbon stocks under no-till systems has generally shown an increased concentration in surface soil, but this may be misleading. Soil can become stratified without tillage so lower levels have less carbon while upper levels have more, but with no change in overall carbon.

Organic practices can, however, enhance carbon with the input of ley crops and manure or compost, so combining these with no-till could result in enhanced surface concentration of carbon and potentially greater total carbon stocks.

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There is also research showing that reduced tillage in organic systems can improve levels of organic carbon, microbial activity and soil structure. Soil microbial activity under organic reduced till or no-till systems is particularly important as it can contribute to improved root colonisation by arbuscular mycorrhizal fungi, leading to more efficient nutrient cycling. This strategy could improve nutrient supply and enhance yields in organic systems.

The TILMAN-ORG research showed that organic producers need not rule out use of reduced till. It does pose challenges but, by adopting a pragmatic and site-specific approach that includes the strategic employment of occasional shallow inversion tillage, it may be possible to realise the benefits of reduced tillage in organic systems without significant loss of yield.

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Related competencies include **Agriculture, Management of the natural environment and landscape, Sustainability**