Green fingers

The core team of TILMAN-ORG, **Drs Paul Mäder**, **Christophe David** and **Julia Cooper**, discuss their aims to develop organic farming and conservation agricultural practices through the TILMAN-ORG project, and what challenges must be overcome

What is the goal of the 'Reduced TILlage and green MANures for sustainable ORGanic cropping systems' (TILMAN-ORG) project?

PM: The goal of TILMAN-ORG is to develop improved organic farming systems through the introduction of conservation agriculture practices (such as less invasive tillage and green manures), which ameliorate soil fertility and biodiversity; improve yield and profitability; and have less impact on climate change through reduced fuel consumption, carbon sequestration and lower greenhouse gas emissions.

Why is there still a level of concern amongst farmers about the agronomic and economic viability of organic farming systems and conservationist agriculture practices? How can these be overcome?

JC: One of our greatest challenges is to improve yields in organic farming. Organic farming systems can only be financially viable and help to feed the world's growing population if we have highly productive systems with high resource efficiency. Through eco-functional intensification we can meet the challenge of balancing productivity with vital environmental services.

CD: Organic farming and conservation agriculture practices often demand new and costly equipment, such as direct drilling machines and special devices for weed control under reduced tillage. These practices are also highly knowledge-based, and this knowledge is not always available. At the technical level, farmers have major concerns relating to the risk of weed infestation and the lack of nitrogen available to plants in Spring. In addition to these barriers, there is also an issue of farmers' attitudes: fields owned by organic and conservationist farmers may not appear as 'clean' as traditional fields, as weeds and decaying mulches are not viewed positively by conventional farmers.

To overcome these problems, we need subsidies for organic and conservation farming, in order to stimulate conversion to these environmentally friendly systems. Educating farmers and advisors is also key to promoting conservation agriculture. In addition to this, there is still a lot of research needed if we are to further develop organic systems combined with conservation agriculture – after all, systematic research in this area only started a decade ago.

A stakeholder group has been built into TILMAN-ORG's structure. Who are these stakeholders, and what is their influence on the project?

PM: The stakeholders consist of farmers, advisors and experts from the machinery industry. At the start of the project, workshops were held in various countries to identify the stakeholders' expectations of the project, and to guarantee that the research activities would eventually help to develop practical solutions for these farmers. We also collaborate closely with farmers in pioneering the improved systems on their farms, and facilitating the exchange of knowledge between stakeholders and researchers, and using farmers' knowledge for prototyping new optimised systems as well.

One of TILMAN-ORG's aims – calibrating farmers' existing decision-support tool NDICEA to assess the effects of reduced tillage options and green manuring on nitrogen cycling and carbon pools – has so far resulted in contradictory results. How will you be taking this forward into the next phase of the project?

PM: After evaluation of all datasets we will have enough data for the NDICEA calibrations. The divergence of the outputs of the NDICEA model is likely connected to the fact that it was developed mainly under humid temperate climatic conditions (Western Europe), whereas we have sites in the north eastern European and Mediterranean climate zones. There is also evidence that the program should include a multi-layer soil routine, in order to better model reduced tillage systems and conventional inversion plough systems.

What are the expected applications of TILMAN-ORG's work, both environmentally and economically?

PM: TILMAN-ORG will identify recommended practices that result in cropping systems which are more productive, financially viable, and which also require less energy and have smaller ecological footprints than traditional farming practices. Farmers will be able to adopt the improved cropping systems on their farms – in fact, the process has already started on pioneer farms.

The research outputs are also particularly interesting for policy makers; the environmentally friendly systems identified may be supported by specific agricultural schemes. Strong links also exist with machinery manufacturers, which will enable the development of a new generation of equipment specifically adapted to reduced tillage systems in organic farming.

Making the most of organic farming

The researchers behind **TILMAN-ORG** are working to change perceptions and improve the efficiency of organic farming in order to break down some of the barriers that can prevent farmers from adopting new innovate practices to make organic farming even more sustainable

ORGANIC FARMING CAN have a number of environmental and ecological benefits. The use of organic manure and the practice of crop rotations (including grass and clover) have been proven to guarantee nutrient cycling and maintain soil fertility, resulting in sustainable crops. Furthermore, long-term experiments have suggested that organic farming has a positive impact on soil life and soil structure, as well as on biodiversity both in the soil and aboveground.

However, organic farming faces a number of challenges. Not only is its economic viability unstable in a marketplace which favours high yielding non-organic produce, but there are also many misconceptions about organic agriculture among farmers who use chemical methods to control pests and enhance crop yield. There have also been challenges within the field of organic farming itself. Whilst over the past two decades new sustainable agricultural practices have been developed using no tillage systems including cover crops and diverse crop rotations (conservation agriculture), the no till system, which is most developed and maintains soil fertility, normally relies on herbicides. Further research is therefore necessary to develop a highly productive and wholly organic system of farming by integrating conservation agriculture practices.

OVERCOMING OBSTACLES

Answering the call for research is the team behind the 'Reduced TILlage and green MANures for sustainable ORGanic cropping systems' (TILMAN-ORG) project. Coordinated by Dr Paul Mäder of the Research Institute of Organic Agriculture (FiBL) in Switzerland and Dr Cristophe David of ISARA in France, TILMAN-ORG is working with international experts, researchers and farmers, and following a transdisciplinary approach in order to overcome obstacles and develop an improved system of organic agriculture by using cutting-edge methods.

As part of the project, Mäder is investigating several approaches to improve crop yield and efficiency. These include making better use of ecological services in agricultural ecosystems by favouring symbiotic nitrogen fixing bacteria (rhizobia), stimulating beneficial root fungi (mycorrhiza) and enhancing earthworm populations for better soil structure.

TILMAN-ORG is also investigating the impact of reduced tillage and year-round green cover on the soil. By assessing the benefits of these different approaches and combining them with other practices favourable to organic farming, such as using new nutrient efficient crop varieties and established biological plant protection methods, TILMAN-ORG hopes to reach a formula that will maximise the potential of organic agriculture.

INDIVIDUAL SUB-PROJECTS

To achieve its goals, TILMAN-ORG's core project has been broken down into six Work Packages (WPs). WP1 provides an overview of reduced tillage under organic farming conditions in Europe and, in WP2, farmers' experiences of reduced tillage and green manures are assessed and their perceptions and preconceptions of reduced tillage and green manures elicited in semi-structured interviews. These qualitative data are then substantiated by quantitative data from medium- and long-term trials of reduced tillage and green manures, together with existing published peer-reviewed and grey literature.

Moving forward, TILMAN-ORG has implemented experimental case studies with respect to yield stabilisation, soil quality and biodiversity. WP3 will assess the environmental impact of reduced tillage and green manures, ie. carbon sequestration; soil microbial activity and community structure; and greenhouse gas emissions, while WP4 has investigated weed management and functional biodiversity of weeds. WP5 is looking at improved nutrient management: data from long-term tillage trials across Europe are exploited to calibrate NDICEA, a decision support tool for farmers, to predict carbon and nitrogen fluxes in the soil-plant system.

Following the experimental and research phases of the TILMAN-ORG project, WP6 takes results from TILMAN-ORG farmers' experiences, case studies and scientific literature, and focuses on designing optimised systems for organic agriculture adapted to various climatic zones in Europe. The sustainability of the systems is assessed by a multi-criteria analysis (MASC)

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REDUCED TILLAGE AND GREEN MANURES FOR SUSTAINABLE ORGANIC CROPPING SYSTEMS

OBJECTIVES

The TILMAN-ORG project's overall goals are to design improved organic cropping systems with enhanced productivity and nutrient use efficiency; more efficient weed management; increased biodiversity; and lower carbon footprints.

PARTNERS

Research Institute of Organic Agriculture, Switzerland; **ISARA Lyon**, France; **Helmholtz Zentrum München**, Germany; **University of Kassel**, Germany; **Louis Bolk Institute**, The Netherlands; **Wageningen University and Research Centre**, The Netherlands; **The Institute for Agricultural and Fisheries Research, Plant Sciences, Crop Husbandry and Environment**, Belgium; **Public Research Center – Gabriel Lippmann**, Luxembourg; **Newcastle University**, UK; **The Organic Research Centre – Elm Farm**, UK; **Estonian University of Life Sciences**, Estonia; **Centro Interdipartimentale di Ricerche Agro-Ambientali**, Italy; **Scuola Superiore Sant'Anna**, Italy; **Universitat de Barcelona**, Spain; **Research Institute of Organic Agriculture**, Austria

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PAUL MÄDER is a biologist, and is particularly interested in processes governing key soil functions. He is responsible for the unique DOK farming system comparison trial, and has been focusing on conservation tillage and beneficial root microorganisms for 10 years.

CHRISTOPHE DAVID is an agronomist who deals with low-input and organic farming systems. His research is focused on design and assessment of sustainable cropping and farming systems with a special emphasis on organic farming systems.

JULIA COOPER is a lecturer in Soil Science at Newcastle University and an active member of the Nafferton Ecological Farming Group within the School of Agriculture.

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in a highly integrative approach. By preparing guidelines for farmers, TILMAN-ORG hopes to address their challenges with regard to weed management and temporary shortages of nitrogen supply. "This will improve yields and yield stability, and reduce carbon footprint, thus improving both the environmental and economic sustainability of organic farming systems," Mäder elucidates.

A PAN-EUROPEAN PERSPECTIVE

TILMAN-ORG benefits from a broad scope and a pan-European perspective which enables it to pool expert knowledge from a range of disciplines and facilitates the exchange of knowledge across national boundaries. Its WP leaders are spread across the continent, and include Dr Julia Cooper from Newcastle University in the UK; Dr Joséphine Peigné of ISARA in France; Professor Michael Schloter of Helmholtz Zentrum München in Germany; Professor Paolo Barberi of the Scuola Superiore Sant'Anna Pisa in Italy; and Ing Sjef Staps of the Louis Bolk Institute in The Netherlands. Mäder explains: "The international outlook has many benefits to offer. It facilitates data mining from various countries, and more general conclusions can be drawn from research results".

TILMAN-ORG has benefited considerably from the multidisciplinary approach brought to it by such an international cohort of project partners. "Interdisciplinary work, applying not only the natural and social sciences but also economics and modelling, is much easier to establish in such a large team, since a critical mass is reached in respective disciplines," elaborates Mäder. "The multidisciplinary approach has so far proven to be extremely successful, in particular in the horizontal research activities – farm surveys; meta-analyses of weeds, soil quality and yields; the multi-criteria assessment; and farm prototyping."

THE RESULTS SO FAR

Although highly dependent on climate, crop and cultural context, the project's initial results suggest that yields achieved with reduced tillage were comparable to those achieved with the conventional mouldboard plough in most cases. TILMAN-ORG's proposed scheme of reduced tillage and green manures also increased soil organic carbon in the upper soil layer, as well as enhanced soil microbial activity and greater numbers of earthworms.

In addition, the project has shown that even though weed infestation and biodiversity are higher in reduced tillage plots than under inversion tillage by plough, it does not compromise crop yield. Green manures can provide an effective means to suppress the growth of weeds and provide nitrogen to plants, and although the impact of reduced tillage systems on carbon sequestration and greenhouse gas emissions remains to be seen, TILMAN-ORG's initial results go some way to addressing farmers' concerns regarding weed infestation and nitrogen supply in reduced tillage schemes.

Taking these results forward, at the end of October this year TILMAN-ORG will be running a three-day internal workshop at the University of Barcelona, dedicated to the functional traits of weeds, nitrogen modelling and farm prototyping. This workshop will fine-tune TILMAN-ORG's methodologies, enabling the project's schemes to be applied on a larger scale.

DATE FOR YOUR DIARY

TILMAN-ORG's project partners will be discussing their findings at the 14th Organic World Congress in Istanbul, Turkey, 13-15 October 2014. For more information about the conference, visit www.owc2014.org.