CORE organic II

TILMAN-ORG

Reduced TILlage and Green MANures for sustainable ORGanic Cropping Systems

TILMAN-ORG
A European Network

Context of the research

No-Till (NT) and Reduced Tillage (RT) are conservation tillage practices with a high potential to restore or improve essential soil functions and mitigate climate change through carbon sequestration and reduced fuel use. While NT systems are widely used in conventional farming, these techniques are challenging to adapt to organic farming due to weed pressure and frequent nitrogen deficiency in early spring. A potential answer may be RT, such as shallow inversion ploughing, or non-inversion tillage. In TILMAN-ORG, the implementation of these practices in European organic farming systems was addressed by an interdisciplinary team of researchers from 11 European countries.

Existing knowledge and experiences

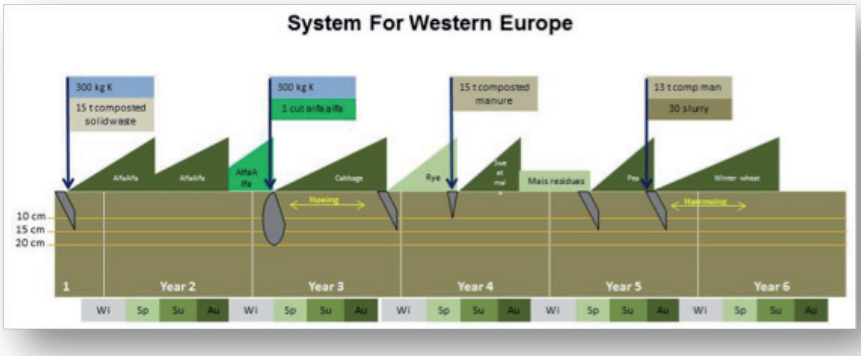
A farmers' survey and an analysis of the existing literature (meta-analysis) has shown that under water limiting conditions, as in Mediterranean areas No-Till (NT) and Reduced Tillage (RT) practices are sustainable forms of management. In regions with higher precipitation levels, the use of green manures combined with less tillage can improve soil fertility. In the long-term, RT will enhance soil quality as indicated by enhanced carbon stocks. In general, crop yields in RT are reduced by 7% compared to Conventional Tillage (CT) with minimal increases in weed competition. Yield reduction due to RT is most pronounced in sandy soils. Shallow ploughing results in comparable yields to deep ploughing, and does not increase weed infestation, but increases carbon stocks. In the view of farmers, weed pressure is seen as the biggest challenge to adapt reduced tillage, improvement of soil quality is the strongest motivation.

Case study: Influence of reduced tillage on soil quality and greenhouse gas emissions
Soil organic carbon, soil microbial biomass and diversity are more stratified in RT as compared to CT and increase in the top soil. However, pre-crop effects on microbial communities are more pronounced than tillage effects. RT positively affects earthworms (number of cocoons, juveniles) and mycorrhizal fungi (spore density and number of species). N2O emissions tend to be higher in RT.

Case study: Weed control and weed diversity
Weeds are more abundant in RT but do not necessarily reduce yields. Weed biodiversity is often higher in RT. The weed composition differs between RT and CT with more perennial plants in RT. A model to assess functional traits of weed communities has been developed. Site-specific weed management strategies are needed.

Case study: Nutrient efficiency and decision support tool
RT may be reducing yields by 8 % due to 15 % lower available nitrogen in spring. This can be compensated by the use of green manure. The N model NDICEA was adapted to simulate impacts of RT on soil organic C and N dynamics, but further improvements of predictive models are still needed.

Prototyping farming systems for major European regions



Prototyping farming systems is a method for assessing current practices and future innovations. Multi-criteria assessment revealed that the strength of RT is a positive influence on biodiversity and the macro-fauna in particular. Weed control is a major challenge in the long-term perspective, confirming farmers' perceptions.

Recommendations to end-users

For farmers – not only organic – the results are encouraging. Weeds can be controlled when applying RT, and green manures are a good strategy in that context. Overall, yields were not impeded substantially if fertilization regimes were adapted. Further development is needed to optimize the timing of nutrient supply, to improve the machinery and to adapt a farm specific reduced tillage system where weeds remain under control in the long-term. RT is especially advantageous for semi-arid regions. Shallow ploughing is recommended, showing positive effects on soil organic carbon, without compromising yields and without increasing weeds. In humid climates, a hybrid system with mostly reduced tillage but occasional ploughing (e.g. for ley destruction or in sandy soils) is promising, but effects on soil organic carbon need to be further studied.

For scientists, the expected stratification of organic matter in RT was confirmed. The higher soil organic matter in the upper-most soil layer increases water infiltration and thus reduces risk of erosion. A new research area could be the in-depth analysis of the microbial response to tillage and pre-crops including green manures, which could be managed to optimize nutrient turnover in the future. Also, the identification of functional traits of weeds is a new area that needs further development and can help farmers benefit from within-field biodiversity. In this approach, positive traits of weeds such as serving as a feed source for pollinators or beneficial insects, or negative traits are categorized and quantified for more than 150 weeds.

Organic NT systems show particular promise in Mediterranean regions where crops can benefit from improved water relations.

Relevance

These results can be easily adopted by conventional farmers and help them to reduce their use of fertilizers and pesticides. NT with herbicides is widely spread in semi-arid regions e.g. in the US or Australia. A reintegration of green manures and a reduced intensity of tillage could help reduce the negative long-term effects of herbicides on the environment while still preserving the benefits in erosion control.

New and important research questions

- Improved understanding of how green manure management and tillage affect N-dynamics and losses of N as nitrate, ammonia and N2O, and identification of strategies to reduce these losses.
- Improved understanding of how green manure and tillage management affect the soil microbial communities that contribute to N and P cycling and losses from soils.
- Improved understanding of how RT with occasional ploughing affects the loss of soil organic matter.
- Strategies for weed control, suitable for specific sites, crop rotations, cultivars, and cover crops (including their management) are needed that comprise new or modified mechanical control and adapted fertilizer use.
- There is a need to better understand how management factors like green manures and tillage intensity interact with local soil types and climates to affect soil structure.
- More research is needed on pest and disease management in RT systems, on the impact of soil structure on weed, N-availability and crop yield, and on the resilience of tillage systems to climate change (e.g. water stress).
- Breeding green manures particularly for the requirements of RT systems (e.g. late sowing) is needed, and also breeding of cultivars adapted to NT and RT such as weed suppression or early vigor.
- Studies on grazing livestock in arable crop rotations could open the field for more management options.

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Find all publications at orgprints.org/view/projects/TILMAN-ORG.html.

Further information

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Read more at coreorganic2.org/TILMAN-ORG.