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A multiple soil ecosystem services approach to evaluate the sustainability of reduced tillage systems

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In the current context of soil degradation, reduced tillage systems (including reduced soil disturbance, use of cover crops and crop rotation, and improved organic matter management) are expected to be good alternatives to conventional system which have led to a decrease of soil multi-functionality. Many studies worldwide have analysed the impact of tillage systems on different soil functions, but overran integrated view of the impact of these systems is still lacking. The SUSTAIN project (European SNOWMAN programme), performed in France and the Netherlands, proposes an interdisciplinary collaboration. The goals of SUSTAIN are to assess the multi-functionality of soil and to study how reduced-tillage systems impact on multiple ecosystem services such as soil biodiversity regulation (earthworms, nematodes, microorganisms), soil structure maintenance (aggregate stability, compaction, soil erosion), water regulation (run-off, transfer of pesticides) and food production. Moreover, a socio-economic study on farmer networks has been carried out to identify the drivers of adoption of reduced-tillage systems. Data have been collected in long-term experimental fields (5 - 13 years), representing conventional and organic farming strategies, and were complemented with data from farmer networks. The impact of different reduced tillage systems (direct seeding, minimum tillage, non-inverse tillage, superficial ploughing) were analysed and compared to conventional ploughing. Measurements (biological, chemical, physical, agronomical, water and element transfer) have been done at several dates which allow an overview of the evolution of the soil properties according to climate variation and crop rotation. A sociological approach was performed on several farms covering different production types, different courses (engagement in reduced tillage systems) and different geographical locations. Focusing on French trials, this multiple ecosystem services approach clearly showed that reduced tillage systems improved soil ecosystem services such as soil biodiversity, water regulation (quantity, quality), carbon storage and soil stability; however, the effects on crop production were more variable (-10% to +7 % range), strongly depending on crop type and agricultural practices (fertilisation, rotation, cover crop). Sociological approach showed that saving labour time and fuel costs were the main motivations for change. Agronomic and environmental benefits are not the trigger but are increasingly recognized and contribute to the maintenance of the practice. Farmers also expressed a need for stronger networking and technical advice, which plays a crucial role. Scientists and experts raise awareness, support collective learning and provide instrumental. Recommendations were provided for sustainable soil management aiming at ecological intensification of agricultural land.