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Changes in soil organic carbon content under annual and perennial crops, and related agricultural practices as observed from a large scale on-farm study in Switzerland

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Abstract: Since 1990, each field topsoil (0-20 cm) of each farm (perennial and annual crops) must be analysed every ten year for Soil Organic Carbon (SOC) content in accordance with international analytical standards, based on a composite sample, as required from Swiss agro-environmental regulation[1]. After data quality control, we used time sequence analyses from about 4000 arable land fields from the cantons of Vaud, Geneva and Jura, and 2000 fields under perennial crops (orchards and vineyards) to quantify the SOC content change rate per year along the past 25 years. We interviewed 300 farmers on a sub sample representative of the cropping systems categories and the overall range of SOC change rates to analyse the relationships between their practices in the past ten years and the observed SOC content change rate. The SOC deficit was quantified based on the soil vulnerability index, namely SOC to clay ratio (Fell et al., 2018; Johannes et al., 2017), with the 10% SOC:clay ratio as minimum desired SOC level. This yielded different deficits ranging from 20% to 80 % of the average SOC content in the Swiss cantons depending on the cropping systems and the soil types, regardless of location and altitude. Vineyards showed the largest deficit. Though the SOC deficit was different between the cantons, the distribution of annual relative SOC change rates was very similar, ranging from -50‰ to +50‰ with a median value close to 0. The average annual change rate, however, was significantly and linearly changing with time, from -4 to -6‰ in the 1995-2000 period to +5 to 10‰ in the present under the different systems with vineyards showing the largest increase. This pattern was identical on all cantons and can be related to the introduction of different mandatory measures in the 1990s such as covering bare soil with green manure, a minimum of 4 crops in the rotation (annual crops), install a grass cover and leave the pruning wood (perennial crops) followed with increasing development of conservation agriculture practices. The detailed analysis of cropping practices and related SOC change rates revealed the major factors allowing for rapid SOC storage and conversely. Moreover, exceptions to the general trends, allowing either to compensate SOC losing practices or jeopardizing storage efforts, were also highlighted. In arable land two performing cropping systems were emerging: polyculture with livestock and conservation agriculture. Gross margins per ha of these systems were equal to or larger than the conventional models. Interestingly, the first positive factor for SOC increase was diversified and intensive cover crops, followed by manure supply. The main negative factor in annual crops was the Soil Tillage Intensity Rating (STIR). The larger the SOC:clay the lower was the effectiveness of the positive factors and the higher the impact of STIR. These results show that the 4‰ COP21 objective is small compared to the actual field-observed results, and the corresponding observations are used to implement the soil carbon sequestration part of the climate plans in the cantons.

[1] https://www.blw.admin.ch/blw/fr/home/instrumente/direktzahlungen/oekologischer-leistungsnachweis.html