FRACTIONAL DEEP TILLAGE TO FOSTER CLIMATE MITIGATION, SOIL FERTILITY AND YIELDS

MICHAEL SOMMER, JÜRGEN AUGUSTIN

Mobile gantry crane system to monitor flux rates of CO_2, CH_4, and N_2O at the long-term field experiment CARBOZALF (AgroScapeLab Quillow)

One of the biggest challenges in global agriculture is to improve soil fertility and yield while simultaneously reducing climate impact as well as nitrogen pollution. Ameliorative soil tillage has been intensively tested as a measure to enhance soil fertility and, thereby, increase crop yield. Generally, an increase in plowing depth leads to a substantial increase of soil organic carbon (CO_2 sink effect) and nitrogen stocks. However, classic deep plowing was often associated with a severe soil re-compaction, followed by reduced yields. In the KRUMENSENKE project, we will develop and test a tillage system that improves soil fertility, increases crop yields and enhances carbon and nitrogen sequestration in soils.

A significant and sustainable increase of carbon sequestration in soils (CO_2 sink effect) – such as the 4per1000 initiative strives for – can only be achieved in soil systems far below their specific C saturation potentials. Previous ZALF research on the effects of soil erosion on carbon cycling in the project CARBOZALF has confirmed this basic principle. After removing the topsoil, i. e. creating an artificial erosion event, and subsequent plowing, a temporary but strong CO_2 sink occurred (approx. 150 g C m^{-2} y^{-1}), as a result of the incorporation of C-unsaturated subsoil into the plow horizon (Ap). In a relatively short period, organic carbon and nitrogen compounds accumulate there, for example by adhesion to soil minerals, until the local equilibrium is reached once again. The same effect can be achieved by deep tillage – but without losing soil fertility as observed after soil erosion.

An ameliorative, fractional deep tillage (aFDT) is characterized by a one-time, partial deepening of the topsoil. In principal, slits of 10 cm width are established down to 50 cm depth by special plowshares. These slits are filled with topsoil, while the removed subsoil is incorporated into the Ap horizon. Leaving undisturbed subsoil in between, slits are created every 70 cm across a field, thus minimizing the risk of a soil re-compaction by heavy agricultural machinery. Adapted plows for aFDT were already developed from the late 1950ies until the late 1980ies at the former GDR »Research Center for Soil Fertility« (FZB, now: ZALF). Extensive research on the effects of aFDT revealed a significant increase in crop yield, which mainly resulted from enlarged rooting depths – hence better access to subsoil water and nutrients – by breaking up existing soil compaction zones at 35 – 45 cm depth.

The interdisciplinary project KRUMENSENKE now studies the effects of aFDT on short-term greenhouse gas fluxes (CO_2, CH_4, N_2O), yield, and long-term trends in soil organic matter (SOM) stocks and pools. A special focus is placed on the question, whether a combination of a FDT with N fertilization via biogas digestate can reduce nitrous oxide emissions while increasing crop yield. KRUMENSENKE applies a multi-scale methodological approach, which combines modern gas flux measurement techniques with proximal soil sensing and drone-based remote sensing of plants and soils. These methods are applied in a newly established manipulation and landscape experiment at the CARBOZALF site and a farmer's field. Here, we will test a new aFDT plow as well. In order to verify the long-term effects of aFDT over decades, historical field trials from the early 1960ies and late 1980ies will be re-analyzed with respect to SOM stocks and SOM pools (especially in subsoils). In addition, the Johann Heinrich von Thünen Institute will carry out the life cycle assessment of aFDT.

Project: Reduction of environmental and climate impacts of agricultural crop production through the use of an optimized topsoil deepening technique (Krumensenke) **Term:** 2019–2022 **Sponsor:** BMEL **Lead at ZALF:** J. Augustin (jaug@zalf.de), M. Sommer (sommer@zalf.de) **Partner:** TIRRECConsult, LEMKEN, TI