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Time course of soil carbon storage, 15N and radiocarbon signature in top- and subsoil of a 60-years agricultural field trial – indications for compensating effects of carbon input and turnover

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Soil carbon dynamics are controlled by the delicate balance between carbon inputs and outputs which both are co-regulated by land use and management (LUM) as important anthropogenic drivers. Upon land use change to cropland carbon stocks generally tend to decline but often the contribution of two opposing factors, namely changes in input and decomposition rates, to soil carbon stock changes is indistinguishable. Here we report on an ongoing cropland experiment in Zurich, Switzerland, named ZOFE (Zurich Organic Fertilization Experiment), established on former grassland in 1949. ZOFE encompasses a range of mineral and organic fertilization practices and a zero fertilizer treatment as control. The experiment has a block design with five replicates per treatment. We make use of productivity and fertilization gradients in selected treatments of the ZOFE trial to evaluate how low or high inputs (induced by differential yields and organic fertilization) may affect soil organic carbon storage and transformation. For the most recent sampling that also included subsoil down to 0.9 m, all properties were measured for every single replicate. Topsoil carbon storage declined after grassland conversion at rates of c. 0.2 t C ha-1 a-1, particularly in treatments with mineral fertilizer and high yields, and without fertilization and low yields. Organic matter amendments such as manure or compost could partially offset but not fully compensate some of the topsoil carbon loss. Over time the soil's delta 15N signature declined as well, probably due to increased atmospheric nitrogen deposition. It increased from the top- to the subsoil, indicating increasing microbial transformation, particularly with manure added. The soil's radiocarbon signature revealed distinct bomb peak patterns in all treatments but only in the topsoil. The 14C data confirmed that with higher productivity more recent organic matter was incorporated, both in top and subsoil. Because, in contrast to topsoil, subsoil carbon storage was similar among treatments, the results tentatively indicate that in the ZOFE trial higher subsoil carbon inputs, owing to high productivity and additional organic amendments, do not enhance subsoil carbon storage but higher inputs are counterbalanced by faster soil organic matter decomposition.