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# Mineral associated and aggregate-occluded soil carbon decreased with increasing nitrogen and residue input for three decades

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Cropland soils may be a source or sink for atmospheric $CO_2$. Therefore, effects of cropland management and fertilization on soil organic carbon (SOC) can be assessed best in long-term experiments. Generally, it is assumed that change in SOC is linearly related to C-input into the soil. However, recently it has been shown that residue incorporation resulted to only small extents in the increase of SOC levels. This gives rise to environmental concerns regarding the efficient use of crop residue. Such concerns are also applicable for the well designed and documented long-term experiment of Puch, Germany, in a silt-loam soil. The crop rotation is winter barley – winter wheat – silage maize. Five organic amendments were combined with N-fertiliser rates. The levels of organic amendments are unamended control (CON), straw was removed; farmyard manure (FYM), straw was removed; straw incorporation (STR); slurry application (SLU), straw was removed; and straw incorporation combined with slurry application (STSL). Three levels of mineral fertilizer application were selected: no nitrogen (N0); medium, 100 kg N ha-1year-1 (N2); and high, 200 kg N ha-1 year-1 (N4). These treatments resulted in a wide range of mean annual carbon input (1 - 5 t C ha-1 year-1). We hypothesize that the amount of soil carbon stored in different fractions will increase with C-input, but the effect will decrease in the order free light fraction (f-LF), occluded light fraction (o-LF) and heavy mineral-associated fraction (HF). Soil samples were fractionated by density using sodium polytungstate (1.6 g cm-3). Compared to the starting value SOC was lost in STR and CON and increased in SLU and STSL, whereas FYM showed no differences to initial carbon stocks. However, N additions resulted in only slightly increase in SOC contents with reference to C-input. The lower amount of o-LF carbon in CON and STR demonstrated the low ability of crop residue in comparison to animal manures to build up SOC contents. Carbon storage increased as expected with N-addition (thus with C-input) in the f-LF. Mineral-associated carbon, however, decreased with increasing fertilization rate. The ratio of o-LF- to- f-LF was strongly decreased with N additions which indicate a saturation of aggregated protected carbon. In summary, we show that increasing amounts of carbon input by crop residue led to decreasing efficiency with regards to SOC storage. This is explained by less relatively occlusion within aggregates and absolutely decreasing storage of carbon in the mineral-associated fraction. We conclude that increased C-input by N-fertilisation decreased storage of carbon in fractions with lower turnover times.