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# Carbon sequestration in croplands is mainly driven by management leading to increased net primary production – evidence from long-term field experiments in Northern Europe

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Sustainable intensification of agriculture in regions with high production potential is a prerequisite for providing services for an increasing human population, not only food, animal feed, fiber and biofuel but also to promote biodiversity and the beauty of landscapes.
We investigated the effect of different management practices on soil fertility and carbon sequestration in long-term experiments, mainly from Northern Europe. In addition, a meta-analysis on the effect of catch crops was conducted. Improved management of croplands was found to be a win-win strategy resulting in both increased soil fertility and carbon sequestration. We quantified the effect of different management practices such as N fertilization, organic amendments, catch crops and ley-arable rotations versus continuous annual cropping systems on soil carbon stocks. Increasing net primary productivity (NPP) was found to be the main driver for higher soil carbon storage. Mineral N fertilization increased soil carbon stocks by 1-2 kg C ha-1 for each kg of N applied to cropland. Ley-arable rotations, being a combination of annual and perennial crops, are expected to have C stocks intermediate between those of continuous grass- and croplands. A summary of data from 15 long-term sites showed that on average 0.5 Mg ha-1 yr-1 (range 0.3 to 1.1; median 0.4 Mg ha-1 yr-1) more carbon was retained in soils in ley-arable compared to exclusively annual systems, depending on species composition, management, soil depth and the duration of the studies. The annual C accumulation rate for catch crops determined in the meta-analysis was well within that range ($0.32 \pm 0.08$ Mg C ha-1 yr-1). Retention factors calculated for straw, manure, sawdust, peat, sewage sludge and composted household waste varied widely in a decadal time scale. Retention of root and rhizodeposit carbon was higher than for above-ground crop residues.
We conclude that NPP is the major driver for C sequestration and emphasize that increased soil carbon stocks not always lead to net sequestration of atmospheric $CO_2$ and that C sequestration not always leads to mitigation of greenhouse gas emissions. The consequences of different land use and management are discussed, taking into account two critical boundaries – the limited area of agricultural land on Earth and requirements to produce sufficient food, fibres and energy for a growing population.