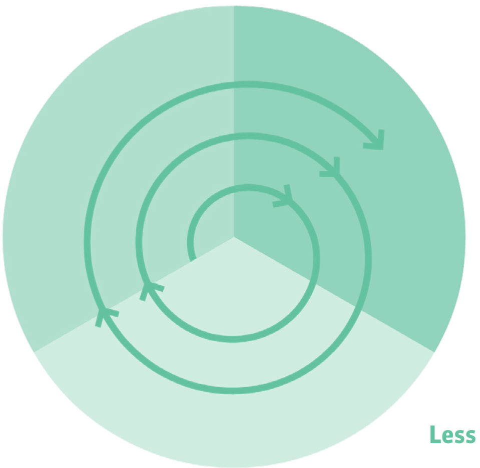
CARBON ACTION
STN MULTA

STN MULTA POLICY BRIEF 1

Farming methods need to be updated in order to manage the carbon stock in agricultural soil – achieving 4p1000 in the Finnish context

Tuomas J. Mattila (SYKE), Juuso Joona (UH), Kristiina Regina (Luke)

On a global scale, agricultural soil contains a significant carbon stock. Relatively small changes in the size of the stock can have a major impact on the climate. In Finland, the carbon stocks in arable land are declining but this development can be reversed by increasing carbon sequestration in mineral soils and by slowing down carbon losses in organic soils.

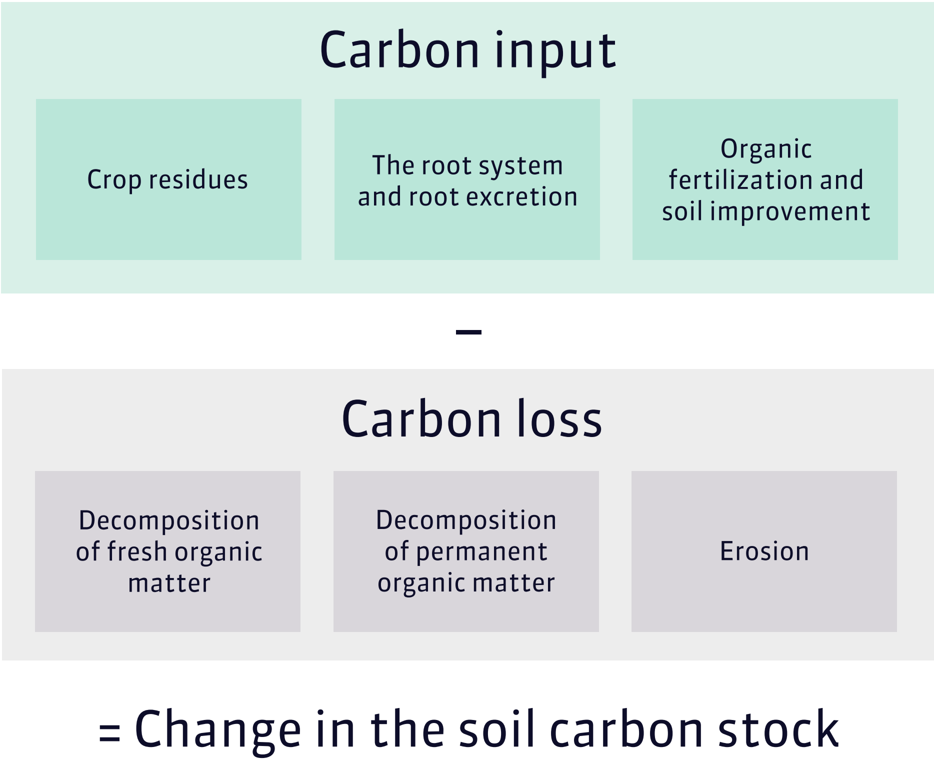


How is carbon stored in soil?

All soil carbon originates from plant photosynthesis. Roots and other plant residues gradually turn into organic matter in the soil through microbial activity. Globally, soil has accumulated a large carbon stock that can be managed to reduce atmospheric carbon dioxide concentrations. Soil carbon stock can be increased through sustainable farming practices (e.g., cover crops, minimum tillage, crop diversification, improved grazing practices, and restoring degraded soils). Finland, together with 45 other countries, has committed to increase the carbon stock of agricultural soils by 0.4% annually (the 4p1000-initiative).

Increasing soil carbon stocks is all about the carbon balance. Adding more organic matter to soil than is lost through decomposition increases carbon stock. Carbon balance can controlled by increasing inputs or by slowing down decomposition. Carbon inputs consist of plant residues, roots, and root exudates, as well as manures and soil amendments. Most of the added carbon is lost as carbon dioxide, but some of it is stored and transported also to subsoil. Microbial activity plays a key role in the storing of the photosynthesis products in the soil, as well as in the decomposition of soil carbon stocks. In carbon sequestration, the carbon dioxide assimilated by plants is stabilized in the soil with the help of microbes. In addition, the accumulated carbon stock is protected by slowing down its decomposition.

Cultivation methods need to be updated in order to manage the agricultural soil carbon stock



What is the current state of arable land carbon stocks in Finland?

About 250,000 hectares (11 %) of Finland's fields consist of organic soils (histosols). The organic matter content in peat soils is over 40 % while in muck soils it is 20-40 %. The c.a. 2,200,00 hectares of mineral soils have an average organic matter content of 6 %. The topsoil layer (20 cm) of Finnish arable land stores approximately 200 million tonnes of carbon. In addition, the subsoil can contain considerable carbon stocks, especially in deep layered peat soils.

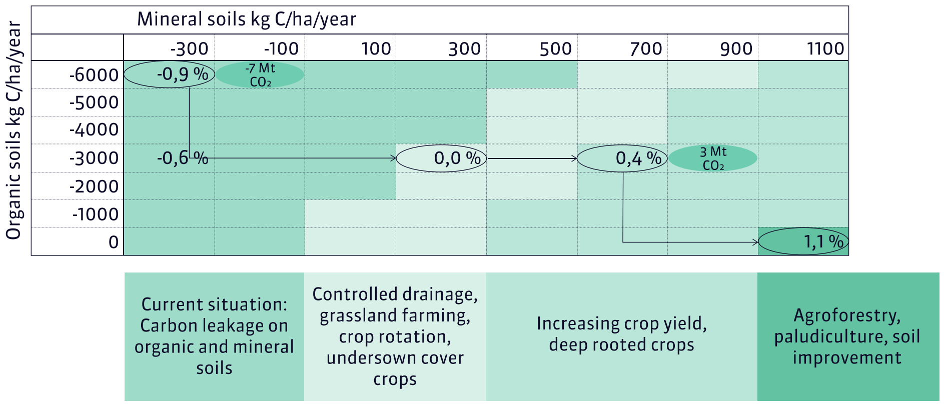
As a result of drainage, liming and tillage in organic soils, the decomposition rate is much higher than the current carbon input. Therefore the carbon stock decreases by about 3000-8000 kg C/ha/year. The trend in mineral soils is parallel (200-300 kg C/ha/ year), but slower decomposition leads to a lower annual loss of carbon. If the goal is to transform this decrease to an annual increase of 0.4 %, farming methods have to be changed for both organic and mineral soils.

Cultivation methods need to be updated in order to manage the agricultural soil carbon stock

What could be possible?

Based on the carbon balance concept, the carbon stock can be increased either by slowing down the decomposition activity or by increasing the input of organic matter (carbon input) to soil.

Emissions from peatlands could be approximately halved by raising the groundwater level (slower decomposition) and by switching to permanent grassland (higher carbon input and less disturbance). In mineral soils, increasing the photosynthesis period through cover crops, winter crops and leys could increase the the carbon stocks by about 300 kg C/ ha/ year. In Finland, implementing these best practices for both mineral and organic soils could achieve net carbon neutrality, where carbon accumulation on mineral soils would offset the loss from organic soils.



To increase soil carbon storage further to the 4p1000 goal, , carbon sequestration in mineral soils should exceed emissions from organic soils. The 0.4% increase could be potentially achieved by improving crop yields, expanding grass cultivation (ley farming), and deepening root systems in mineral soils. At this stage, agricultural soils could be a net sink, but the carbon loss in organic soils would continue.

Using experimental and novel land management options, the carbon sequestration potential could be further increased, but the methods have not been tested under local conditions. For example, paludiculture (cultivation of wet-tolerant crops in rewetted peatlands) stops carbon loss in peatlands, but requires novel crops. In mineral soils, better grazing practices, agroforestry, and the use of external soil amendments have resulted in remarkably rapid increases in carbon stocks in some scientific experiments. The potential for scaling these high-intensity measures to the whole agricultural area is limited, but they could be targeted to fields with degraded soil condition.

Increasing carbon sequestration can be beneficial for food production. Organic matter improves water holding capacity and crop yields and decreases runoff. Better soil health may increase productivity, and higher crop yields will increase carbon input in the soil. Farmers' interest in improving soil health is increasing and new management practices are spreading from farmer to farmer. However a shift in the subsidy system could accelerate the transformation to carbon sequestering agriculture.

Considerable climate benefits could be achieved using current best practices (controlled water table on peatlands, cover crops, continuous vegetation cover, and improved crop rotations). Changing farming methods requires agricultural education to help farmers develop the skillset to implement these practices on their farms.

Finland, together with 45 other countries, has committed to increasing the carbon sinks of agricultural soils in the 4p1000 initiative launched by France. According to the initiative's calculations, an annual increase of four per mille (4 ‰) of carbon in arable land would significantly reduce the amount of CO2 produced by human activities in the atmosphere. In Finland this would mean sequestering 3 million tonnes of carbon dioxide in the soil, or 6 % of total greenhouse gas emissions. Today, Finnish fields are a source of greenhouse gas emissions. The carbon loss in mineral soils is 0.5 million tonnes and in organic fields 6.4 million tonnes of carbon dioxide per year. Finland's total emissions in 2017 were 56 million tonnes carbon dioxide equivalents.

References

Bradford M. et al. (2019) Soil carbon science for policy and practice. Nature Sustainability 2, 1070–1072.

Chenu C. et al. (2019) Increasing organic stocks in agricultural soils: Knowledge gaps and potential innovations. Soil and Tillage Research 188, 41–52.

Heikkinen J. et al. (2013) Declining trend of carbon in Finnish cropland 1974-2009. Global Change Biology 19 1456-1469.

Kätterer T. et al. (2011) Roots contribute more to refractory soil organic matter than above-ground crop residues, as revealed by a long-term field experiment. Agriculture, Ecosystems & Environment 141, 184-192.

Minasny B. et al. (2017). Soil carbon 4 per mille. Geoderma 292 59-86.

Paustian K. et al. (2016) Climate smart soils. Nature 532 49-57.

Teague W.R. et al. (2016) The role of ruminants in reducing agriculture's carbon footprint in North America. Journal of Soil and Water Conservation 71, 156-164

Tilastokeskus (2016). Kasvihuonekaasuinventaario.

Tilastokeskus (2019). Kasvihuonekaasuinventaario.

Zomer R.J. et al. (2017). Global sequestration potential of increased organic carbon in cropland soils. Nature Scientific Reports 7.

CARBON ACTION
STN MULTA

strategic RESEARCH

www.carbonaction.fi

STN MULTA is a project (no. 327223, 2019-2025) funded by the Strategic Research Council and led by the Finnish Meteorological Institute. It belongs to Carbon Action platform coordinated by the Baltic Sea Action Group. The Carbon Action platform researches and promotes carbon sequestration, regenerative agriculture, and a climate-smart food system. www.carbonaction.org/stn-multa/