Fact sheet

Soil Carbon Check

Testing for Life

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Soil Carbon Check explained

Soils have a high potential for storing carbon and can therefore contribute to mitigating climate change. On a global scale, about 1.5 * 10^{15} kg of soil organic carbon (SOC) is stored in the upper meter of the soil, which is about three times the amount of carbon in the aboveground biomass and twice the amount of carbon as there is carbon dioxide in the atmosphere. The more carbon in soil, the less carbon dioxide in the atmosphere.

Besides the impact on the climate, carbon sequestration has important advantages for farming systems. Organic matter plays an important role in soils; it has an effect on physical (e.g. soil workability, water holding capacity, root penetrability), chemical (e.g. potassium-, calcium-, and magnesium binding capacity) and biological (e.g. soil biodiversity, disease suppression, nitrogen and sulphur mineralization) components. Not all organic material applied to the soil will be retained. In mineral soils, organic matter decomposes at a rate of around 2% per year on average. In practice, this is dependent on place and time and carrying out measurements is the only way to be certain of the actual amount of carbon in the soil.

Soil Carbon Check is a unique soil test that provides insight into the carbon contents of the soil. It also tracks the development of soil organic carbon over time, and therefore the amount of carbon dioxide removed from the atmosphere. It is recommended to use the Soil Carbon Check every year so that it is possible to display the significance of an increase in soil organic carbon. Soil Carbon Check uses an analysis technique called near-infrared spectroscopy (NIRS), which is quick, economical and environmentally sustainable.

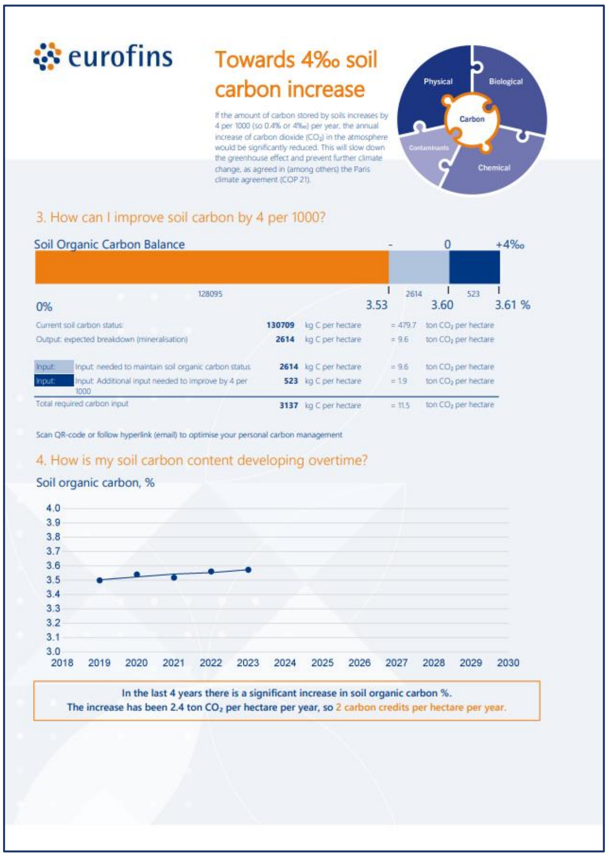
Most farming systems have the potential to increase soil organic carbon and improve their soils. How this should be done, varies per farm. The concept is simple: plants photosynthesize and capture carbon dioxide in organic material, i.e., leaves, stems, fruits and roots. All non-harvested biomass can theoretically become soil organic matter. However, farming systems are complex and therefore a suitable set of solutions should be selected. Reducing tillage, sowing green manures, agroforestry, permaculture, crop selection / rotation and application of manure / compost are a handful of possibilities. The online tool **Carbon Calculator** provides insight into how measurements taken on the farm will affect soil organic carbon, helping to optimize the farming system.

Analysis methods

Soil Carbon Check uses the near infrared spectroscopy (NIRS) method. NIRS for solid materials was developed in the 1960s. It allows for the fast, quantitative, non-destructive, and cost-effective estimation of multiple physical, biological and chemical soil characteristics from the same spectral data, once sufficient large data sets have been established. Eurofins Agro started with the NIRS system for forage analysis in 1986 and for soil analysis in 2003 and since then has analyzed over 1,000,000 soil samples. All parameters analyzed with NIRS have a wet chemistry reference method. In this way, Eurofins Agro has been able to match the NIRS spectra with increasing precision to soil parameters that have been widely used in agronomy. More information about the analysis methods used in Soil Carbon Check can be found in Reijneveld *et al*. (2023)[1].

Report

The Soil Carbon Check report is divided into four questions; the parameters answer these questions. Page one of the report shows how much carbon is captured in the soil and how stable the carbon is. Page two shows how soil carbon can be improved by 4 per 1000 and how the carbon content develops over time.



[1] Reijneveld, J A, van Oostrum, M J, Brolsma, K M, Oenema, O. Soil Carbon Check: A tool for monitoring and guiding soil carbon sequestration in farmer fields. Front. Agr. Sci. Eng. 2023, 10(2): 248–261

Parameters shown on the report

Soil organic matter (SOM)

SOM is the collective term for all (decomposed) biomass in the soil that originates from micro-organisms, soil and plant material. SOM consists of carbon (C), oxygen (O), hydrogen (H), nitrogen (N), phosphate (P) and sulphur (S). Organic matter has many important functions in the soil and is therefore one of the most important indicators of soil health. Organic matter is food for soil life and an engine of all soil functionality.

Organic matter enters the soil through means such as the supply of crop residues (leaves, stems and roots), animal manure, green manuring and compost. Bacteria, fungi and other soil organisms break it down until only indigestible residues remain. This decomposition process occurs in several steps involving all organisms of the soil food web. Decomposition is rapid at first and then slows down. It can take decades for freshly applied material to be fully converted to stable organic matter.

Soil organic carbon (SOC)

SOC is the major component of SOM. It is the most important measurement in the Soil Carbon Check.

Soil inorganic carbon (SIC)

Soil inorganic carbon (SIC) consists of mineral forms of carbon, either from the weathering of parent material or from the reaction of soil minerals with atmospheric CO_2. Inorganic salts containing carbon can appear as carbonate. The gasses carbon dioxide and carbon monoxide are also classed as inorganic carbon.

Carbon dioxide (CO_2)

To track its effect on climate change, soil organic carbon storage can be expressed as CO_2 storage. For this, a factor 44 (molar mass CO_2) / 12 (molar mass C) = 3.67 is used. This means one tonne of stored soil organic carbon corresponds to 3.67 tonnes of captured CO_2.

Percentage of SOC in SOM

The percentage of SOC in SOM can range from 45-60%. The more SOC in the SOM, the less nitrogen and sulphur present. More SOC in SOM is an indicator of stability. The organic matter is then less easily broken down by soil life, and therefore there is also less decomposition.

Total carbon

The total carbon (TC) is the sum of SOC and SIC.

Active carbon

Approximately 1-4% of SOC is active carbon. This is determined with the POXC (permangeate-oxidizable carbon) method. Permanganate-oxidizable soil C is used as proxy for active SOC, to detect early management-induced changes in SOC contents. Among other things, integration of legumes in the cropping system, an increased rotation in arable farming systems, and reduced tillage lead to increased amounts of active carbon. Active carbon reflects the effect of farm practices that promote organic matter accumulation or stabilization and can therefore be a useful indicator of long-term carbon sequestration.

C/N ratio

The carbon over nitrogen (C/N) ratio is a measure of the amount of nitrogen that can be released during decomposition of organic matter. The lower the C/N ratio, the easier the breakdown. With a higher C/N ratio, the breakdown of organic matter is more difficult. A high C/N does not necessarily mean something is wrong.

Optimal C/N ratio is, in part, dependent on your management goals. For example, a high C/N implies little decomposition of organic matter, and the organic matter that remains present has positively impacts workability, carbon sequestration, and water storage. A low C/N ratio positively impacts nutrient availability (nitrogen mineralization) as it encourages microbial activity. The ratio can be affected by soil management; input of straw and solid manure will eventually increase the C/N-ratio.

C/S ratio

As with N, the carbon over sulphur (C/S) ratio relates to the quality of the organic matter in the soil. A low C/S ratio indicates good sulphur mineralization, whereas a high C/S indicates the opposite. It is possible to have two soils with identical SOM levels, but with different C/S ratios, dependent on the quality of the organic matter.

Clay

Particles smaller than <2 µm form for the clay fraction of soil. The smaller the size of a particle, the greater the relative surface area for adsorption. Clays – and there are many types of clay with different properties – have a large external surface area and some also have a large internal surface area between layers. Due to this, clay particles can hold nutrients such as magnesium, potassium and calcium well and provide a basis for a fertile soil.

Clay / SOC ratio

The clay / SOC ratio is an indicator of the structural condition of the soil. Generally, the soil structure quality increases with a decreasing clay / SOC ratio. A clay / SOC ratio of 8:1 is an average for a very good structure quality, whereas a clay / SOC ratio of 13:1 or higher is less favorable (Johannes et al., 2017)[2].

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[2] Johannes A, Matter A, Schulin R, Weisskopf P, Baveye P C, Boivin P. Optimal organic carbon values for soil structure quality of arable soils. Does clay content matter? Geoderma, 2017, 302: 14-21

Bulk density

The bulk density is the weight of a soil in a given volume. The bulk density is influenced by the composition of the soil material, organic matter content, and the degree of compaction. Bulk density is reported in the method section of the Soil Carbon Check and plays a vital role in the background: to calculate carbon / CO_2 storage per hectare, the total mass of soil should be known (derived from bulk density). Eurofins Agro uses a pedotransfer function developed by Hollis et al. (2012)[3] to predict bulk density based on analyzed soil characteristics, in which particle size and organic carbon content are the biggest factors.

Estimated mineralization

Estimated mineralization in the upcoming season is calculated with a model describing the breakdown of organic matter in the soil. The model used is based on the MINIP model, developed by Yang[4] (1996) and Yang & Janssen[5] (2000). It describes the breakdown of organic matter over time. The expected mineralization (%) for the coming seasons is calculated with this model, and the calculated amount of SOC that will be broken down this year is given on the report. This shows how much SOC should be brought back to the field, to compensate. To sequester carbon, the input of SOC should be higher than the mineralisation. In addition to the parameters given on the report, pH and microbial activity are analysed and used in the mineralization model.

Additional input to increase with 4‰

The 4‰ initiative[6] originated from the UN Climate Change Conference (COP21) in Paris. The aim is to neutralize the impact of worldwide CO_2 emissions by increasing soil organic carbon in agricultural soils with 4‰. Soil Carbon Check reports how much soil organic carbon input is required to achieve this.

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[3] Hollis J M, Hannam J, Bellamy P H. Empirically-derived pedotransfer functions for predicting bulk density in European soil. *European Journal of Soil Science*, 2012, **63**(1): 96 – 109

[4] Yang H S. Modelling organic matter and exploring options for organic matter in arable farming in northern China.
Dissertation for the Doctoral Degree. Wageningen: *Wageningen University*, 1996

[5] Yang H S, Janssen B H. A mono-component model of carbon mineralization with a dynamic rate constant. European *Journal of Soil Science*, 2000, **51**(3): 517 – 529

[6] The international "4 per 1000" initiative: https://4p1000.org

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