Technical Information

Advice Sheet 45: Soil Carbon Check Service

Introduction

The environmental impact of agriculture and creating a sustainable approach is ever more crucial on a global scale. The focus on climate change has brought attention to the levels of carbon stored in agricultural soils. There is a need for an international approach to measuring soil carbon stocks to increase the understanding of carbon sequestration. This can be done at a farm level by monitoring the soil organic carbon.

Changes in soil organic carbon can be difficult to recognise as they often occur gradually over many years. Effectively monitoring change requires a suitable sampling strategy, an accurate analysis of organic carbon in soil and an estimate of the bulk density at a specified sampling depth.

This advice sheet describes the NRM analytical service for providing an accurate assessment of the carbon stored in soils, applicable to both grassland and arable systems. This provides a calculated organic carbon stock (tonnes per hectare at specified sampling depth) as well as a range of other useful parameters.

Selecting the right Carbon Check package

There are two packages NRM offer, Carbon Check (A421) and Carbon Check Plus (A422). Both packages contain the following analysis and calculations, to give a complete audit of the carbon contained within the soil profile that was sampled:

- Organic Carbon Stock (tonnes per hectare)
- Soil Organic Carbon (SOC %)
- Organic Matter %
- Total Nitrogen %
- Total Carbon %
- Carbon: Nitrogen Ratio
- Soil Inorganic Carbon (SIC %) & Carbonate Class
- Bulk Density kg/l

In addition to these Carbon Check Plus also includes the analysis of Active Carbon. This is a measure of the proportion of organic carbon accessible to soil microbes and as such is a useful Soil Health indicator. It is more responsive measure than organic carbon so allows for changes to be detected in a shorter time frame. It is a precursor to the build-up of soil organic matter providing a useful soil management tool and guide to long term carbon stores.

Sampling

The accuracy of the soil sampling is fundamental to meaningful analytical data. Please read the following advice to make sure you get the full benefit of the carbon check service.

1. **Plan where to take samples** – identify different areas or zones by considering the environmental landscape, soil type, land use and areas where different treatments have been applied. Once the areas have been divided into several relatively homogeneous units, called strata, apply random sampling within each stratum. Avoid patches with animal manure, animal pathways, field entrances, areas near water / feed troughs and other unusual features.

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2. **Sampling depth** – The Food and Agriculture Organisation of the United Nations report on measuring carbon stock specifies a sampling depth of 30cm to account for the differences in the soil profile. On shallower soils samples should be taken as deep as possible. The depth sampled should be provided on the request form accompanying the samples (otherwise assumed to be 30cm for carbon stock calculations).
3. **How to sample** – a minimum of 5 cores should be taken at random within each strata to make a composite sample (a greater number of cores provide a more representative sample and the number taken should be appropriate to the size of the area covered). A clean auger should be used to take cores over the area in a W pattern.
4. **Preparing the samples** – mix the soil cores for each composite sample in a clean container and remove all roots, plant material and accumulated surface organic matter. Select around 300g and put in a labelled grip seal bag.

Stones will be removed from the sample prior to preparation in the laboratory. In calculating the carbon stock of the area sampled the estimated stone content can be accounted for to get a more accurate representation. This information should be provided on the analysis request form (otherwise assumed to be zero).

Monitoring changes of soil carbon stock levels should be done every 4 – 5 years and it is important that it is always done at the same time of year to reduce sampling variation.

Analysis

Total Carbon and Total Nitrogen by combustion

A portion of the dried and ground soil sample is combusted in pure oxygen at 1200°C. The resultant gas mixture containing carbon dioxide and nitrogen oxides is led by carrier gas through a splitter. The carbon dioxide content is measured by IR detector. Nitrogen oxides are reduced to nitrogen by passing through a copper reduction oven and the nitrogen determined by TCD detector.

Organic and Inorganic Carbon by combustion

A portion of the dried and ground soil sample is acidified with orthophosphoric acid and sparged at 150°C. The gas mixture containing carbon dioxide from the carbonates present in the sample are led by carrier gas to the IR detector. This determines the amount of inorganic carbon present in the sample. The organic carbon is the difference between the total and the inorganic carbon (TOC = TC – TIC).

Bulk Density (disturbed method)

A known volume of prepared soil sample (dried 2mm) is weighed to determine the kg/l. This is different to the undisturbed core method. It is used with the sampling depth to convert the organic carbon from a weight basis to area.

Active Carbon (permanganate oxidisable carbon)

Dried and ground soil samples are mixed with permanganate for a fixed time period and the absorbance of the supernatant measured by spectrometer. The amount of carbon oxidised is a function of the quantity of permanganate reduced. This is the active or labile form of carbon.

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Report

The report will comprise of the analytical results, carbon stock calculations and a summary of the different analysis carried out. Please ask if you require an example of this report.

Organic Carbon Stock (t/ha)

Organic Carbon Stock gives a total organic carbon value in tonnes of carbon per hectare of land to the specified sampling depth. This calculation factors in the measured soil organic carbon %, stone content, sampling depth and bulk density.

Active Carbon (mg/kg)

Active or Labile Carbon is the portion of carbon which readily breaks down and provides an active source of nutrition to soil microbes. Changes in soil management such as cultivation methods or the use of cover crops, can be monitored with active carbon analysis as it is a precursor to long term build-up of organic matter.

Soil Organic Carbon %

Soil Organic Carbon (SOC) is the carbon component of soil organic matter. It is a diverse group of carbon-based compounds originating from the decomposition of plant material, animal residues, soil fauna and biota. The level of SOC is influenced by environmental factors and management practices. It is a key measurement in monitoring changes in the levels of carbon stocks.

Organic Matter %

Soil Organic Matter is a complex mixture of all organic material found in the soil including living components (plant roots, microorganisms) and dead components (leaf litter, humic substances). It increases the soil's water holding capacity and provides a slow release source of energy for microorganisms which increases the cycling of nutrients within the soil. This report uses the Van Bemmelen factor of 0.58, to convert Soil Organic Carbon to Organic Matter.

Although it is not possible to specify critical concentrations for soil organic matter (dependant on mixture of farming system, soil type and climate) it is important to maintain and, where possible, increase levels.

Total Carbon %

Total Carbon is the measure of all carbon forms within the soil which are primarily organic or inorganic. Total carbon is different to Total Organic Carbon, which refers specifically to the organic carbon fraction.

Total Nitrogen %

Nitrogen is the main driver of plant growth and is associated with soil organic matter. It is mobile in the environment and present in many different compounds some of which are available for uptake by plants. Total Nitrogen is the measure of all forms of nitrogen (organic and inorganic) in the dried sample.

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C:N Ratio

The proportion of organic carbon relative to nitrogen (C:N ratio) gives an indication of the right balance for soil microbes to aid the release of nutrients. The optimum C:N ratio for nitrogen release in soil is between 10 and 12.

Inorganic Carbon/ Carbonate Class

Soil Inorganic Carbon (SIC) comprises of carbonates and bicarbonates which are abundant in alkaline soils. The SIC forms a reservoir in the soil and the levels can be subject to change with biological and environmental factors that influence the precipitation of solid $CaCO_3$ or the emission of gaseous CO_2.

The calcium carbonate content of the soil is determined from the SIC and used to assess the calcareous nature of the soil – non-calcareous, slightly calcareous, moderately calcareous, very calcareous and extremely calcareous.

Bulk Density

The Bulk Density of a soil gives a good indication of how well plant roots can grow and explore the soil for nutrients, and how easily air and water can move within the soil profile. The Bulk Density of the soil is used to calculate the Organic Carbon Stock.

How to submit a sample for analysis

- Complete the Carbon Check analysis request form with the sample references and client code selecting the package required (A421 = Carbon Check, A422 = Carbon Check plus).
- Provide the sampling depth (this is needed for the carbon stock calculation; if this is not completed a depth of 30cm will be assumed).
- Estimate the stone content of the area (this will be factored into the carbon stock calculation if provided, otherwise assumed to be 0%).
- Ensure the samples are in clearly labelled, well sealed bags and carefully packaged.

To arrange delivery of sample bags and courier bookings please contact Customer Services:

E-mail: enquiries@nrm.uk.com

Tel: 01344 886338

References

Measuring and modelling soil carbon stocks and stock changes in livestock production systems, guidelines for assessment. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, 2019

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