FACTSHEET

GREATSOILS

Measuring and managing soil organic matter

Figure 1. Well structured clay loam soil in an arable rotation with organic matter distributed throughout the topsoil (credit: Simon Cowell)

What is soil organic matter?

Soil organic matter is the term used for all living, or once-living, materials within, or added to, the soil. This includes roots developing during the growing season, incorporated crop stubble or added manures and slurries. All organic matter contains carbon (C), but it also contains nitrogen (N), phosphorus (P), sulphur (S), potassium (K), magnesium (Mg), calcium (Ca) and a whole range of micronutrients (e.g. copper, (Cu) and zinc (Zn)).

Soil organic matter is found in all sorts of forms with a range of ages. If we look very carefully at the C atoms, we find some that were fixed from carbon dioxide by photosynthesis last week and some that date back over 10,000 years. The intermingling of organic matter with minerals from the underlying parent material (geology) is a key process in soil formation.

Organic matter is more than half carbon. Researchers more often talk about soil organic carbon than soil organic matter, but these are different ways of measuring the same basic soil property.

To help understand how organic matter cycles in the soil and how it affects soil processes, we usually consider organic matter as three main pools:

- Fresh plant residues (litter, decaying roots) and small living soil organisms
- Decomposing (active) organic matter
- Stable organic matter, often linked tightly to the clay minerals (sometimes called humus)

Some soils also contain very stable materials that were originally organic matter, such as charcoal and coal fragments.

What does soil organic matter do?

Organic matter adds to soil fertility and overall soil health by enhancing the physical, chemical and biological properties of soil (Figure 2):

- Fresh plant residues fuel biological life in soil
- The amount of active decomposing organic matter in soil has a large impact on biological properties, nutrient cycling and soil structure
- Stable organic matter changes the colour of soil and adds significantly to the active surface area, thereby changing the physical and chemical properties and processes in soil. This is very important in sandy and light silty soils

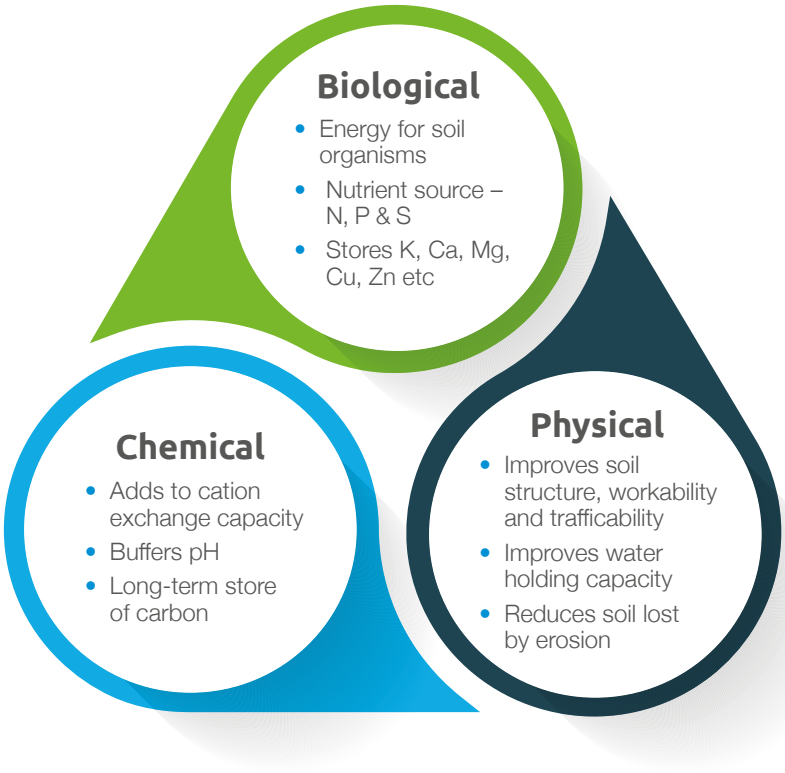

Figure 2. The main roles of organic matter in soils

How can I add organic matter to my soil?

The levels of organic matter in any soil are a result of the equilibrium between the inputs of organic matter and the decomposition of the organic matter by soil organisms. The disruption of soil aggregates during tillage changes the distribution and accessibility of organic matter in soil and usually increase rates of decomposition.

Inputs vary through the year as crops grow and the amount and activity of roots change. Return of crop residues also increases inputs of organic matter to soil; this occurs with improved crop yields or the introduction of cover crops to a rotation. Inputs might also be added from outside the field/farm in manures, composts and biosolids. The actual impacts depend on loading rate (rate and frequency of application) – it can take a number of years of repeated management for changes to occur, particularly soil structural improvements.

In general, the simple rule is: add more organic materials, build more soil organic matter.

The amount of organic material applied to soil is usually given in t/ha but be careful to take account of whether this is the total amount or a dry weight. Organic materials can range widely in their water content from only 10% to 90%. The amount of carbon applied is closely related to the total dry matter application; each tonne of dry matter contains about 580 kg of carbon.

Work shows that, although increases in soil organic matter are positively related to the amount of organic matter added, not all organic matter inputs have the same impacts (Table 1).

Experience has shown that improvement in productivity in arable systems after improved organic matter management takes some time to appear. Defra research has shown measurable benefits of improved organic matter management, in addition to any nutrient supply benefits, but these are often only realised after at least six years of implementation. AHDB research suggests that farmers should first consider the nutrient value of any imported materials. Once these have been taken into account, it is rarely economic to spend more than a further £30 per tonne (dry matter) of organic materials added to soil per hectare (including the costs of material, haulage and spreading).

Figure 3. Muck spreader (credit: ADAS)

Spring crops have been shown to have the highest direct yield benefits from improved organic matter management, especially in years with extreme weather; this is likely to result from better establishment and more rapid rooting.

Table 1. Typical range of impacts seen for different inputs of organic materials imported to the field/farm

Organic Material		Impacts on			
	Examples	Soil biology	Soil structure*	Readily available N	Other nutrients
Solid: 'stable'	Compost	Moderate improvement	Moderate improvement	Low	Many materials supply important quantities of P and other nutrients. See the ***AHDB Nutrient management guide (RB209)*** for details
	Biosolids	Some improvement	Moderate improvement		
Solid: 'active'	FYM	Large improvement	Large improvement		
	Poultry manures	Moderate improvement	Little or no improvement	High, N loss by volatilisation or leaching likely	
Liquid	Slurries & Digestates	Little or no improvement	Little or no improvement	High, N loss by volatilisation or leaching likely	

* The impacts on soil structure summarised here assume it is possible to make a timely application of the bulky organic materials, so no compaction results from the application process itself

How much organic matter is in my soils?

The amount of organic matter present in a soil depends on:

- The input of organic materials and their decomposition rate
- The rate of existing soil organic matter decomposition
- Soil texture (ie sand, silt and clay content)
- Environmental factors such as soil moisture, temperature and aeration

There is little consistent scientific evidence that there is a critical threshold of soil organic matter, above or below which soil properties change significantly. Instead, it is important to measure soil organic matter periodically over time in order to determine the direction of change and understand the impact of management practices.

Organic matter is naturally concentrated at the soil surface and decreases with increasing depth unless inversion tillage takes place.

Sampling and measuring organic matter

The amount of organic matter in soil is relatively large compared with the changes that result from management over a short period of time. Hence, sampling to monitor changes in soil organic matter should take place regularly and, ideally, always at the same point in the rotation, but it is usually not useful to measure organic matter every year. Trends can usually be detected for a field using samples collected in the same way at 3–5-year intervals over a decade or more. Detecting changes in the total soil organic matter in the field is often a slow process.

The presence of roots or added organic materials (residues, manures, composts) in the sample can give odd results, so obtaining a well-mixed representative sample for analysis from a number of separate soil samples collected in the field and mixed together is very important.

The most common method used to estimate the amount of organic matter present in a soil sample is by measuring the weight lost by an oven-dried (105°C) soil sample when it is heated to 400°C; this is known as 'loss on ignition', essentially the organic matter is burnt off. In research laboratories, it is more common to measure the total carbon content of the soil (after removing any mineral carbonate) by dry combustion and elemental analysis; the amount of carbon measured can be converted into an estimate of organic matter (and vice versa). Where you are trying to detect changes over time, it is important that the same method is used each time, as variations in the results from the same sample can result from the use of different temperatures, duration of heating and pre-treatments.

The natural levels of organic matter that can be held in a sandy soil are much lower than in a heavier soil because of the ways in which clay can stick to and stabilise organic matter in soil. A good level of organic matter for a sandy soil would be considered too low in a clay soil. It is important to take into account both soil texture and climate when assessing organic matter levels in soil.

What is critical? Ensuring there are regular additions of organic matter to 'feed' the soil is more important than achieving any particular measured value of soil organic matter.

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Further information

AHDB provides a range of practical information on improving soil management for farmers, growers and advisers. Whether you need an introduction to soil biology or a detailed guide to soil structure AHDB has the information and guidance to support you. Information for grassland, pig producers, arable and horticultural crops is available at **ahdb.org.uk/greatsoils**

You may also be interested in:

- Soil structure and infiltration
- Soil health and water supply
- How to count earthworms
- Compost is good news for soil health
- Soil pH – how to measure and manage it based on an understanding of soil texture
- Soil assessment methods
- An introduction to soil biology
- Soil Food Web

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