Profiting from soil organic matter

A guide to improving soil organic matter management that can increase farm profits and help farmers to meet Cross Compliance and Environmental Stewardship Requirements
Soil – a primary asset

Soil is a key farm asset and most farmers and growers are well aware that sustaining and improving their soils makes good sense. Despite this, soil organic matter content across the country has declined steadily over the past few decades and this trend, if allowed to continue, could well endanger the viability of many farming enterprises and ultimately the long-term sustainability of UK agriculture and our environment.

Good soil management can reverse this trend and improve farm performance. For example, strategies that lead to an increase in soil organic matter can lead to improved yield in drought years, fertilizer and seed savings, and reduced irrigation requirements.

The need to improve the soil organic matter status of soils is central to the Government’s strategy for sustainable farming and food production. Perhaps more importantly, the changes involved can increase the financial return for your business.

A guide to better practice

This is a guide to help farmers and growers to assess what soil organic matter management practices are appropriate to their farming system. It is based on the findings of a Defra-funded research project that studied the first-hand experiences of more than 200 farmers and growers across the UK who have shown there are measurable financial and management benefits from improving the organic matter content of their soils.

A wide range of farm case studies are available that describe how organic matter is managed on arable, livestock and mixed farming systems. Some that appear relevant to your farm enterprise are included with this guide. They provide detailed management information together with an assessment of the costs and benefits.

More detailed information, including case studies, is available at www.keysoil.com, so you can see in detail how these benefits were derived.

Case study – pig waste as an organic matter resource on a mixed arable farm

For more than 10 years a 320ha mixed arable farm with a 300 sow pig unit on medium to heavy loam has used pig waste as farmyard manure on potatoes with any surplus going on cereals. Oilseed rape residues were incorporated and barley/wheat straw was baled for use in the pig unit with any surplus sold off. The farmer saved inorganic fertiliser equivalent to 60-80 units/year for up to three years, with particular savings on potassium applications.

However, the main benefits were a steady increase in potato yield of 3t/ha over 10 years, and an increase of 0.5t/ha on the third wheat crop. The downsides were an increased need for a growth regulator on wheat and costs being greater than benefits for the first two years. By the 10th year net farm profit had increased by over £60/ha annually. But if the muck handling cost is included as a necessary cost against the pig business the net profit rises to £84/ha.

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Soil organic matter is...

...simply a material which was once part of a living organism or produced by one. It occurs naturally in soils and comes from decomposing animals, plant roots and crop residues. But more can be added to improve the soil – various materials such as farm yard manures, straw, and composts are often used.

Most organic matter added to a soil decomposes over a few years as animals and microorganisms feed on it. This process releases nutrients for the crops to use. During this period of decomposition, organic matter is often called the active fraction and this fraction can quickly change with changes in soil management practices.

Most of the remaining organic matter does not break down so easily – it can take many years, even centuries, for it to decompose. This more stable matter is often referred to as humus.

Both active and stable soil organic matter make important contributions to binding soil particles together into stable aggregates that give soil its crumb-like structure. They improve a soil's workability, root penetration, and water and nutrient holding capacity.

It is important because...

Soil organic matter can be both financially and environmentally beneficial to a farm enterprise. Here are just some of the reasons why soil organic matter is so important:

- Water and air enter and circulate more freely in the soil
- Roots penetrate more easily
- Water-logging and surface water is reduced which in turn reduces soil erosion risks
- Crops establishment and growth benefit from improved water and nutrient availability
- Soil workability is improved which reduces cultivation costs
- Workability window is expanded
- Soil is more resistant to compaction and disturbance during cultivation
- Storage and supply of plant nutrients – N, P, K and micro-nutrients - is improved
- Cation exchange capacity which governs nutrient availability for plant uptake is improved
- Soils need less lime because of improved soil pH buffering
- Carbon and energy are available for soil microorganisms that cycle nutrients and fight plant diseases
- Contaminants are bound up reducing the negative environmental effects of pesticides, heavy metals, and other pollutants.

Forms of organic material in soil

1-5% living organisms
0-10% fresh residue
5-10% active fraction
75%+ stable humus

Fact – Falling organic matter levels

Organic matter levels have fallen in arable and ley-arable soils over the 15 years between 1980 and 1995 according to surveys undertaken by the National Soil Resources Institute. The largest falls were on grasslands ploughed up for arable use and on cultivated peaty or organic soils.

Case study – active organic matter management on an arable farm

An arable farming business showed a net benefit of £27/ha annually after 7 years incorporating straw as organic matter. This was after taking into account the £20/ha that was ‘lost’ by not selling on the straw to a local contractor.

The 986ha farm has grown wheat, oil seed rape, and peas in rotation since the 1960s on heavy clayey soils developed on chalky till. Wheat straw and other crop residues were incorporated from 1993 onwards with very noticeable improvements after 1998. Fuel costs for cultivations fell by 20-30% and cultivation time was reduced by 10%. It was noticeable that in places where straw was not incorporated for a year, tractors worked harder – in a lower gear requiring more power to maintain the same productivity.

Significant benefits also came from small areas of previously compacted and water-logged land where yield mapping had shown local wheat gains of up to 4t/ha. In general, the yield loss in very wet and very dry years was around 10% lower where organic matter has been regularly incorporated and there were some savings in fertiliser application.

The costs of incorporating straw in this area were relatively low and so even though the benefits were modest it made good sense to invest in this option. The internal rate of return on the investment was over 50% - far more than the annual return on most other farm investments.

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Options available to you...

W hat you can achieve depends on the source of organic matter and the management options available to you. For example, do you want to build organic matter quickly to improve drought resistance, supply nutrients for immediate use by crops, or gradually improve soil structure over a number of years?

Organic matter resources

Generally a green residue, such as grass or vegetable remains, will release large quantities of nutrients, particularly nitrogen, during decomposition by soil micro-organisms. Whereas a poor quality bulky residue, such as cereals straw, can be up nutrients. One way of selecting the most appropriate organic matter amendments for your soil is to use the carbon:nitrogen ratio (C:N). All organic matter contains carbon (C) and nitrogen (N). Micro-organisms use up quantities of nitrogen for their own metabolic processes and so the relative amount of nitrogen will determine whether nitrogen, and other nutrients, will be available as the material decomposes.

Animal manures, typically, have low C:N ratios depending on the amount of bedding mixed with them. They release their excess nitrogen quickly and so they act like a fertiliser. If you use animal manures in NVZs or in water pollution risk areas you will need to account for their nutrient content in your manure management plan.

In contrast straw has a high C:N ratio and releases little nitrogen in the short term. It can even tie up available nitrogen in the short term. It can even tie up available nitrogen in the short term. If you use straw as a soil conditioner it is best to use it in the spring. Mineralisation of available nitrogen is then getting underway which prevents the excess straw from releasing much nitrogen. The biological activity of the organic matter resource may also influence your choice of organic matter. Composted manures and municipal wastes have low biological activity since most of the microbial action has already taken place. They are relatively stable and add directly to soil humus to improve water holding capacity and workability. Fresh manures and raw green matter are much more biologically active, but they can only release their carbon and nitrogen after being processed by soil micro-organisms. These materials are well suited to forming soil aggregates that improve soil structure.

C:N ratio for a range of organic materials

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
<th>Rapid N release</th>
<th>Slow N release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay</td>
<td>Straw</td>
<td>Poultry manure</td>
<td>Pig manure</td>
</tr>
<tr>
<td>Woodchip</td>
<td>Bark chips</td>
<td>Municipal biosolids</td>
<td>Grass clippings</td>
</tr>
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The following describes some resources:

- Farmyard manure and slurry - often the most readily available on-farm resource. They are great for increasing soil nutrient levels but only provide a temporary boost of nitrogen. They are often effective in building up soil organic matter.
- Green manures - these are nitrogen-rich organic materials that can be used to increase soil nitrogen levels. They are often used in soil management plans to improve soil structure and nutrient content.
- Poultry litter - this is a nitrogen-rich organic material that can be used to increase soil nitrogen levels. It is often used in soil management plans to improve soil structure and nutrient content.
- Composts - these are organic materials that have been broken down by micro-organisms. They are often used in soil management plans to improve soil structure and nutrient content.

Biodegradable waste, such as shredded newspapers, can be used to create compost. Composts can be used to improve soil structure and nutrient content. They are often used in soil management plans to improve soil structure and nutrient content.

Bio-solids - nutrient-rich organic product of wastewater treatment, otherwise known as sewage sludge. Treated to reduced odour and sterile pathogens, often available free of charge with professional nutrient management advice. Applications must comply with The Sludge Regulations (contact NetRegs for more details).

Straw - incorporated straw stable or imported chopped straw. Operational costs and sale income forgoed can be offset by net benefits.

Bio-solids - nutrient-rich organic product of wastewater treatment, otherwise known as sewage sludge. Treated to reduced odour and sterile pathogens, often available free of charge with professional nutrient management advice. Applications must comply with The Sludge Regulations (contact NetRegs for more details).

Paper pulp - paper and cardboard processing, de-inked, often available free of charge. Composted, lime-stabilised or raw shreddings can be used, subject to waste management regulations (contact NetRegs for more details).

Composts - composted garden and municipal green waste. Many local authorities deliver to licensed open windrow facilities built on farm (contact WRAP and local authority for more details).

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Assessing organic matter content

In order to effectively manage soil organic matter it needs measuring – not just to know how much is there but also to see how it is changing.

The KeySoil range

There is no fixed level of organic matter or C content for a particular location - rather there is a range which is determined by soil clay content, land use or agricultural management, and various environmental factors such as rainfall and temperature.

A number of methods exist to measure organic matter in soil. The simplest way is to heat soils and measure the change in weight as organic matter is burnt off. Given that soil organic matter consists of a significant and consistent amount of carbon – approx 60% – measuring the carbon content of a soil is also a common way of assessing its organic matter content. By comparing your current soil organic matter content to the KeySoil Range you can make a preliminary assessment of the potential for change for that soil.

Measuring changes – ‘KeySoil Status’ and ‘KeyC’

To predict whether organic matter will change over time the KeySoil Status tool uses simple information to estimate the organic matter needs of your soil and compares these needs to the returns that will be achieved through your current and planned management. This provides an indication of how your soil organic matter content is likely to change over time.

Measurement of total soil organic matter is not sensitive enough to pick up small changes in organic matter that indicate whether it is increasing or decreasing. Soil contains a large amount of stabilised organic matter (humus) and so it is difficult to accurately measure small changes against this large background.

To overcome this problem a new, simple method of measurement KeyC based on the active fraction of organic matter has been developed at Rothamsted Research. Experiments show that the KeyC is sensitive enough to use as an indicator of change in soil organic matter content within 2-5 years of a change in management.

Changes in agricultural management, improving profitability and delivering environmental benefits.

A well cared for soil is profitable as an agricultural resource and delivers important environmental benefits. It is less likely to be eroded and will resist runoff, protecting our streams, rivers and waterbodies from pollution by nutrients, pesticides and sediments.

Agriculture can contribute to the national carbon balance and managing organic matter plays an important role. For example, bio-energy can be produced from crops and their residues. Recycled organic wastes diverted from landfill, where they produce harmful methane, can be used to improve the soil. Improved soil organic matter status provides savings in farm energy use and can lead to reductions in the use of fertilisers produced from oil.

Despite their fundamental importance, soils are often managed in ways that ignore their full potential, in both agricultural and environmental terms.

It is for this reason that we developed KeySoil – Unlocking Soil Potential.

A carbon approach

Carbon plays a crucial role in maintaining the quality of our environment. Plants need carbon dioxide to grow and they take this from the atmosphere and convert it into carbon compounds, producing organic matter during the process of plant photosynthesis. If this organic material and the carbon it contains is incorporated into the soil, animals and micro-organisms feed on it to get energy releasing carbon back to the atmosphere in the form of greenhouse gases.

This turnover of carbon - the natural carbon cycle - is approximately 20 times the emissions from energy use and land use change. Additionally soil represents an important store of carbon being approximately twice that in the atmosphere as carbon dioxide and two to three times that in plants.

Small changes in the turnover of carbon and the amount of carbon stored in plants and soil can have a significant impact on the balance of greenhouse gases in the atmosphere either contributing to or mitigating climate change.

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Further information

Contact
This brochure is produced as part of a project whose experiences will help the England Catchment Sensitive Farming Delivery Initiative (EC SFDI) to provide advice that is based on good science and a sound understanding of farmers’ needs. It will also help to inform Defra policy.

More information about this Defra funded research project (SP08014) can be obtained from Dr Nicola Hall at:
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Email: Nicola_hall@gya.co.uk

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Email: Saran.sohi@bbsrc.ac.uk

* The EC SFDI is delivered in partnership by Natural England, the Environment Agency and Defra.

More about KeySoil
This project uses the KeySoil KeySoil enables you to explore opportunities to improve soil organic matter management on your farm. The KeySoil tools are simple to use and accessed online. More information about KeySoil and the tools can be found at www.keysoil.com

If needed, a KeySoil Advisor can work with you and your management team to help you assess the potential impact on your business of changing the way you manage organic matter. Contact information:
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