KEYSOIL
Unlocking Soil Potential

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

Profiting from soil organic matter

Improving soil organic matter management on your farm typically produces net benefits between £60 and £100/ha annually depending on your farming system.

A recent in-depth study of the costs and benefits of soil organic matter management practices confirmed that these benefits can be realised in as little as 2-5 years. Benefits will vary from farm to farm depending on the farm systems but overall some 85% of farms studied showed financial gains from improving soil organic matter management.

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, fertiliser 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.

Some of the strongest benefits of economic value identified by farmers and managers of arable and mixed farms:

- Better crop establishment
- Increased crop yield
- Improved seed rate
- Reduced fertiliser requirements
- Reduced crop lodging
- Reduced disease occurrence
- Fewer cultivation passes
- Reduced drought stress
- Longer workability window
- Reduced water-logging
- Reduced sub-soiling frequency

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 a few years as animals and micro-organisms 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 micro-organisms that cycle nutrients and fight plant diseases
- Contaminants are bound up reducing the negative environmental effects of pesticides, heavy metals, and other pollutants.

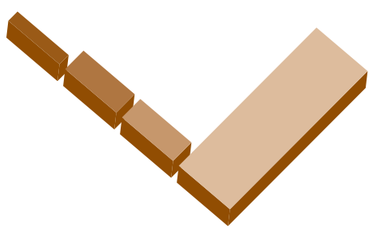
Forms of organic material in soil

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 were 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.

Options available to you...

What 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 cereal straw, can tie 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 soil as it decomposes. Such materials are useful for building good long-term soil structure with all the associated benefits. Nitrogen becomes available in the longer term when the micro-organisms themselves are recycled.

C:N ratio for a range of organic materials

Here is a guide to relative C:N ratios for a range of common organic materials. More detailed information should be available from your commercial supplier.

High *Poor N release*	**Low** *Rapid N release*
Newspaper	Poultry manure
Sawdust	Dairy manure
Cardboard	Pig manure
Woodchips	Municipal biosolids
Bark chips	Grass clippings
Maize stalks	Vegetable waste
Straw	Hay

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.

Soil management practices

Various well established practices are used to maintain and enhance soil organic matter:

Cover crops/green manures – useful winter or break crops. Examples include legumes (clover and lupins), forage brassicas, buckwheat and other cereals. Crops can be autumn sown and ploughed in the following spring. Using surplus cereal grain makes this a low-cost option. Improved soil condition and stability are achieved as well as value in fodder or oil seed yield.

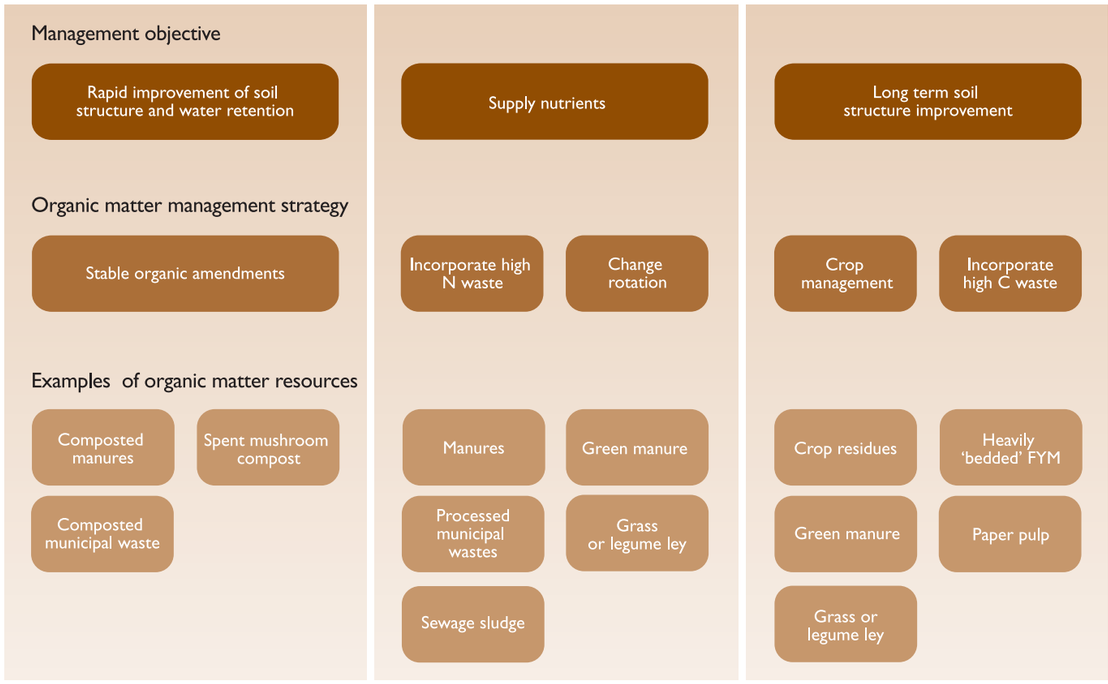
Grass ley – grass or clover/grass adds significant organic carbon in arable rotation.

Choice of break crop – introducing a break crop such as oilseed rape or oats into the rotation can provide an opportunity to improve soil organic matter. Oilseed rape is deeper rooting, and provides root and stem material for incorporation into the soil. Oats produce fibrous roots and good levels of organic matter return, especially where straws are incorporated.

Conservation tillage – crop establishment systems that involve shallower cultivation and fewer passes than traditional systems, usually accompanied by incorporating crop residues. Helps to conserve soil organic matter and reduce risk of compaction and capping.

Timely cultivation – early crop establishment of over-wintered crops significantly reduces the risk of soil erosion, one of the main ways in which organic matter is lost from vulnerable soils.

Rough seed beds – leaving fields in course tilth over winter reduces the risk of water and wind erosion.



Organic matter resources

Together with changing your management practice incorporating appropriate organic matter resources can be central to improving soil organic matter. The following describes some resources:

Farm yard manure and slurry – often the most readily-available on-farm resource. Reallocation within a farm can often optimise economic benefits. Share and trading schemes maximise local resources, for example, swapping straw for farm yard manure with a neighbouring livestock farmer can benefit both businesses.

Poultry litter – some farms with poultry units, or waste management companies handling poultry waste, will provide poultry litter as a soil improver for agricultural land. It can supply good quantities of nutrients as well as organic matter. Farmers must be aware of guidance on animal by-products to ensure low risk to livestock from poultry pathogens (see further information).

Bio-solids – nutrient-rich organic product of wastewater treatment, otherwise known as sewage sludge. Treated to reduced odour and sterilise 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 stubble or imported chopped straw. Operational costs and sale income forgone can be offset by net benefits.

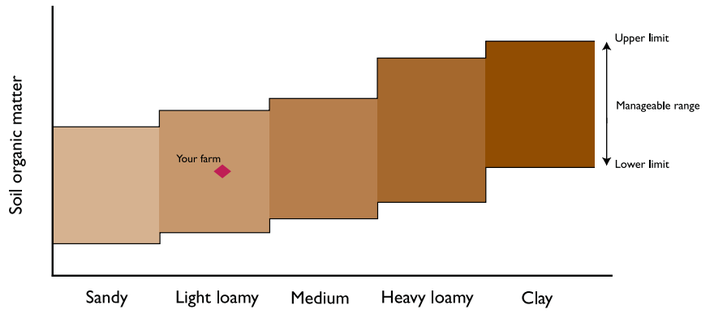
Industrial and municipal waste – pulp from paper and cardboard processing, de-inked, often available free of charge. Composted, lime-stabilised or raw shreddings can be used, subject to waste management regulations (contact Netregs for more details).

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).

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



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.

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.

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.

www.keysoil.com

Further information

Contact

This brochure is produced as part of a project whose experiences will help the England Catchment Sensitive Farming Delivery Initiative (ECSFDI)* 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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Case studies illustrating soil organic matter management practices can be obtained from the website www.keysoil.com

The research report for the first phase of the Soil Carbon project called '**To develop a robust indicator of soil organic matter status**' is available on the Defra Science web pages by putting the code SP0310 into the search engine http://randd.defra.gov.uk/

More information about long term experiments on soil carbon in agricultural systems, and Rothamsted's research on carbon cycling can be obtained from Dr Saran Sohi at Rothamsted Research. www.rothamsted.bbsrc.ac.uk
Email: Saran.sohi@bbsrc.ac.uk

* The ECSFDI 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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Links

WRAP (Waste & Resources Action Programme) is a company supported by funding from DEFRA, the DTI and the devolved administrations of Scotland, Wales and Northern Ireland. www.wrap.org.uk

The Composting Association provide information and support to compost producers and users. www.compost.org.uk

Information on compliance with environmental regulations on spreading of non-agricultural waste such as sewage sludge or industrial waste products can be obtained from the NetRegs website www.netregs.gov.uk

Information about the Single Payment Scheme Cross Compliance requirements can be obtained from the Cross Compliance Helpline:
Tel: 0845 345 1302. www.crosscompliance.org.uk

Further details of the help and advice available to comply with the NVZ Action Programme measures are provided on the Defra NVZ web pages at http://www.defra.gov.uk/environment/water/quality/nitrate/help.htm

Animal By-Products Regulations apply to waste from animal producers, providing guidelines on the use of poultry litter containing carcass material as fertilizer to spread on agricultural land. www.defra.gov.uk/animalh/by-prods

The UK Soil Management Initiative (SMI) is an independent organisation created to promote the adoption by UK farmers and advisers of systems designed to protect and enhance soil quality. www.smi.org.uk

PLANET is a PC software version of Defra's industry standard 'Fertiliser recommendations (RB209)' book, available free of charge with supporting guidance and bulletins. www.planet4farmers.co.uk

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