

Soil



Why soil?

Ever since the international year of soils in 2015, the vital importance of soil has been increasingly acknowledged by farmers, growers and agriculture policy makers alike. We know that without soil, most food production becomes all but impossible; and we recognise that some of our food production systems are leading to unprecedented levels of soil degradation.

We are learning what we need to do to improve soil health and function. Key to this is a better understanding of soil biology and how our practices interact with the fauna and flora in our soils.

Reliance on inorganic inputs and limited crop returns to soil means that in many areas, we are seeing a [decline in levels of Soil Organic Matter \(SOM\)](#). Organic matter consists of living and dead material, both of which are vital to soil functioning.

Resources:

[Think Soils: examining soil structure, The Environmental Agency](#)

[An introduction to soil biology, AHDB](#)

[Seven Ways to Save Our Soils, Soil Association](#)

Author: Liz Bowles, Head of Farming at the Soil Association



Organically-managed soils and farmland can maintain soil fertility, enhance biodiversity and improve [water retention capacity](#). It can even be part of the solution to mitigate climate change through [increased soil carbon sequestration](#).

The Soil Association vision is that soils must be living entities, full of organisms that are essential to maintaining productive capacity. Every farm has different soil types, and an understanding of how to manage your own is key to maintaining their health and productivity. Best management practices will vary depending on soil type but getting it right shouldn't only be seen as a challenge. Custodians of healthy soils will see benefits for their business, and will be recognised by a society that increasingly acknowledges the value of healthy soil.

Your soil - know what you've got and make it work for you



Soil is every farm's greatest natural resource. Making the most of it can seem daunting, especially when there is such a wealth of scientific information around.

Honestly, it's about getting the basics right.

Understanding your soil means looking at its mineral, structural and biological health - a problem with any of these factors can cause major issues for you and your farm. Knowing what soil you have and what state it's in can give you the knowledge to make good decisions for your business.

The GREATsoils team have reviewed the different ways you can assess your soil health. Some are very simple while others involve expensive testing under laboratory conditions. All of them can tell you something about your soil, but you have to make best use of that information to ensure the test was worthwhile. What you choose depends on your situation, inclination and budget. If you haven't tested your soil for a while, do the basics first. Get a simple soil analysis test, then get out and dig some holes – they're cheap to do and you can learn so much.

Author: Lyn White, Agricultural
Development Manager

Physical

The most valuable tool on your farm is your spade.

Digging holes, or soil pits, is a great way to see your soil's physical appearance. There are easy indicators: look for signs of compaction, worm numbers, colour and size. Notice how your soil smells, how well it breaks up, its rooting depth and its colour. Making a [visual and hands on evaluation](#) of your soil at a number of points across a field will help you discover where your compaction is and its depth, helping you to target any remedial work. Best of all, digging costs nothing but time.

Your soil - know what you've got and make it work for you



Chemical

At a basic chemical level, you'll want to know your pH, P (phosphorus), K (potassium) and Mg (Magnesium) balance. For this you'll need to get your soil analysed. It doesn't need to be the whole farm at once. Look at the fields that aren't performing, or any that you're planning to reseed. If you test 20% of your land every year, in five years you'll have tested it all. It is worth remembering that soils in arable rotation require routine testing more frequently than soils under permanent grassland and typically should be checked every three to five years.

Resources:

[Soil testing companies, Soil Association](#)

[Strategies for soil sampling, Soil Association](#)

[Which Soil Test to Use, GREATSoils](#)

Biological

Soil biology explains the complex web of soil ecology that turns dead plant and animal material into available nutrients. While a lot can be learned from looking at soil physically, to understand the fungi, the bacteria, and the nematodes that lead to the physical breakdown of organic matter, you'll need to dig a little deeper. The most common method of starting to measure soil biology is to focus on soil organic matter (SOM). A typical test will differentiate between the labile, stable and inert fractions of the SOM. Most businesses offering soil analysis services will also offer a SOM measurement. Often SOM levels are slow in responding to management changes, suggesting measurement should be taken every five years rather than more frequently. There are some [new and interesting ways](#) to assess microbial activity in your soil or you could try [Bait lamina sticks](#) – where the amount of bait eaten measures biological activity.

Systems design: taking a step back

It's hard to look at soil health in isolation. Almost every business decision you make impacts your soil; the crops you choose, the machinery you use, your stocking densities. All your actions will either deplete, maintain or enhance your soils. So, if you want more productive, healthy soils you may need to take a step back and look at your farm as a whole.

Put simply, farm systems fall into those that are stock-based, mixed and stockless. Whatever your system, there are things you can do to make it more soil-friendly. Introducing cover crops and green manures will build your soil fertility on a stockless farm, whilst extending the rotation and bringing in a greater variation of crops with different rooting depths will improve soil structure and workability. Planting a leguminous herbal ley would benefit soils in stock-based systems. On a mixed farm, you might decide to extend the fertility-building grass ley stage of your rotation, so that your soils are more productive for your cash crops. Each year, consider tweaking your system to benefit your soil.



The trend in farming systems over the last fifty years has been towards greater and greater specialisation, with most farms now focusing on a single enterprise. This may suit you and your farm, but if you are considering diversification there are some interesting business models that can benefit both the soil and your bottom line.

Introducing Livestock

Bringing livestock back to arable farms is no small undertaking. You'll need significant investment in infrastructure, not to mention time and skills for husbandry. But if you're interested in the fertility building benefits you could consider extending your rotation by renting to a livestock business.

Author: Paul Flynn, Soils and Arable Advisor

Systems design: taking a step back

Working Together

Even without livestock, we're seeing more collaborative approaches to rotations. It has become normal for farmers to rent out fields for short periods to vegetable growers looking for fresh land, though sometimes the consequences for soil health can be less than positive. However, there are now more and more [examples of farmers](#) co-operating in this way, working together to focus on soil health through the life of the whole rotation and agreeing on crops to grow whilst taking account of what's in the best interest of the soil.

Even Trees?

For a long time, trees on farms were something that got in the way of the combine. But increasingly, their benefits for the whole farm are being understood. Agroforestry means incorporating trees with other farming enterprises. By either grazing livestock (silvo-pastoral) or growing crops (silvo-arable) you can benefit from two crops on the same acre. Plus, you'll be protecting your soil from run-off, building soil organic matter and providing protection for crops and livestock from extreme weather.

Resources:

[Case study: Alan Scofield: Profit through trees, Soil Association](#)

[Improving Soils for Better Returns, Beef and Lamb AHDB](#)

[Dr Paul Hardgreaves - Soil Compaction: problems and remedies, SRUC](#)



Rotations: make them work for you and your soil

For centuries, our arable farming systems were based on the Norfolk four-course rotation which originated in the East of England. Rotations consisted of two cash crops and two crops to feed livestock and would have included legumes for fertility building, and livestock to graze and provide manure directly to the field.

The last sixty years have seen many farms replace the fertility building phase and livestock with artificial fertilisers. While allowing much shorter rotations, this has had unintended consequences for soil organic matter (SOM) levels and soil structure. However, where crop rotations tend to be longer we are seeing higher levels of organic matter. A recent review of studies from all over the world demonstrated that organically managed soils are [21% higher in SOM](#).

The main components of an organic or agroecological rotation:



Green manures and grass leys

These normally include a nitrogen fixing crop like clover or Lucerne, and a grass such as Rye or cocksfoot that build carbon through their fibrous roots and bulky tops. Farmers are opting for diverse leys with additional species like chicory and a range of legumes.

Cash Crops

Nitrogen demanding cash crops, such as wheat, potatoes or cabbages, are usually grown immediately after the fertility building phase. As a general guide, the amount of N available in the first year will be around 40–60% of the total amount of N in the legume, with [much smaller amounts of nitrogen available in following years](#). In the later years of the rotation, less nutrient demanding crops, such as oats, triticale or carrots are usually grown.

Author: Haydn Evans, Head of Farming, Cymru

Rotations: make them work for you and your soil

Break crops

Generally, these are non-cereal or grass crops and are important in the arable component of mixed systems, as well as on stockless farms. Break crops can reduce disease and weed and pest competition.

Cover

Periods of bare ground between cash crops should be kept to a minimum. Green cover captures sunlight which will benefit subsequent crops, and reduces the leaching of valuable nutrients. Bare soils are also vulnerable to weeds and erosion.

Intercropping

This is used for a [wide variety of reasons](#), including reducing inputs and combatting weeds. Additional plants can also serve as another crop – it's worth thinking what the market opportunities may be.

Resources:

[Organic crop rotation factsheet, Soil Association](#)

[Rob Corlett - Where in the rotation should you apply nutrients, Pollybell Organic Farm](#)

[Blog: Farmers working together for soil health, Soil Association](#)



Benefits of extending a rotation

Weed control: Cover crops can out-compete or restrict some weeds.

Using the whole soil profile: Crops with different rooting depths and rooting structures are important for ensuring the whole soil profile is exploited.

Balancing your nutritional requirements: Calculating a nutrient management plan for the rotation will help to ensure the nutrient supply for each crop in the rotation will be adequate. There are many decision [support programmes](#) freely available to assist with this.

Pest and disease disruption: Diversity in cropping through the rotation is key to reducing the ability of any pest or disease to gain a foothold. Diversity within the field can also be helpful.

Working the soil

The majority of soil breaking actions are carried out to produce a seedbed and establish a crop, although activities such as subsoiling, soil aeration and mole ploughing are carried out as remedial actions primarily for compacted soils. Weed suppression with hoes and other mechanical weeding machinery also break the soil. As we learn more about the impacts of breaking and turning over the soil, the need for such cultivations are increasingly being questioned.

More and more farmers are seeking ways of minimising their cultivations to limit this damage. Whilst groups of farmers are actively investigating methods to [reduce reliance on the plough](#), to date most organic farms use it to control weeds, and incorporate organic matter from one crop, in preparation for the next. Despite the disruption caused by ploughing, organically farmed soils have an average of 21% more soil organic matter (SOM), so if you get the machinery and timing right, appropriate cultivation can be an [important part of building healthy soils](#).

The damage to soils from machinery will depend on the time of year, depth of cultivation and frequency of such actions, as well as the soil type itself. Such actions turn the structure of the soil and all the SOM producing flora and fauna upside down. Excessive use of heavy machinery can reduce SOM, as soil microorganisms are damaged and [less able to re-establish their ecosystem](#).



Agroecological weed control

Weed control by 'out competing' or avoiding weed seed germination should be the first port of call. Undersowing crops or bi-cropping offers effective ways to reduce weed seed germination, alongside the use of cover crops prior to crop establishment. One way to think about weed control is that if we need to use a mechanical weeder, it should be because all other techniques to prevent weed seed germination have failed.

Mechanical weed control can be highly damaging to soil microorganisms, particularly fungi. Ideally you want to limit cultivations as much as possible by optimising timing and making sure that the technique used is as benign as possible. Weed control techniques like flaming, hand pulling (on bed weeders) and brush weeding, tend to be less disturbing than tractor pulled hoe or mechanical cultivators.

Author: Jerry Alford, Soils and Arable
Advisor

Working the soil



Deep cultivations

Subsoiling is the chief cultivation method to address deep compaction. Other techniques include mole ploughing and soil aeration. These are used to remedy problems caused by previous cultivations, machinery use on land at times of year when the soils were incapable of carrying such a load, or where livestock poaching has occurred causing soil pans.

Such cultivations can improve soil drainage, root penetration and, in some cases, increase water availability. Deep rooting green manures, such as lucerne and chicory, can also help to break up soil structure. All cultivations will cause disturbance to soil life and should only be used where there is clear evidence of compaction.

Timing

When using any technique designed to alleviate compaction, timing of operations is key to avoid smearing and further damage to soils. As well as damage to soil structure, incorrect timing of cultivations can lead to nitrogen leaching. In organic rotations, autumn incorporation of grass clover leys is the riskiest time for nitrate leaching as drainage rates may be high and crop growth slow. So, where possible, incorporate leys for spring cropping and consider fields adjacent to watercourses as your priority.

Resources:

[Case study: John Cherry on no-till and soil Health, Innovative Farmers](#)

[Case study: James Lee: A flexible approach to cultivations, Soil Association](#)

[Cultivation for your soil type, Soil Association](#)

Soil management

Getting the most from your soils means actively managing them, anticipating problems and implementing changes to prevent damage and build soil fertility. Not only is healthy soil more productive, it's easier to manage too. If your soil is in good heart it will drain well, and can be more resilient against compaction and poaching. Likewise, cover crops are going to protect you from run-off. All this said, things can go wrong, so here are a few key areas where soil management will pay off.

Run-off and erosion

Soil erosion can result in reduced nutrient storage capacity, poorer soil structure, and decreased water holding capacity and soil depth. The key to avoiding soil erosion and nutrient run-off is good management: sound rotations, maintaining cover, appropriate cultivation and efficient nutrient management. Avoiding late-harvest crops like maize and potatoes in vulnerable fields is important. Some areas will be vulnerable to wind as well as water erosion. Maintaining soil organic matter content and ensuring good soil structure will help protect from the wind, and shelter belts can have an effect over a distance up to 20 times their height.

Drainage

Around half the UK's farmland requires drainage to allow it to achieve its maximum potential. Although the capital cost is high, the potential impacts are significant, leaving soils more productive, less vulnerable to damage from machinery and grazing livestock, and responding better to good management. It can also reduce the loss of fertiliser and pesticide to water.

Poaching

Poaching is a problem. Not only does it cause direct physical damage to the crop and the soil, leading to bare patches, there is also an increased risk of erosion, leaching and invasive weeds. Protecting grazing swards from the risk of poaching requires good management of stocking densities, feeding procedures, sufficient forage supplies, and appropriate housing to accommodate stock when field conditions are unsuitable for grazing. There is interesting work being carried out by farmers increasing their stocking densities for short periods, using the system known as mob-grazing.

Author: Chris Atkinson, Head of Standards and Best Practice at the Soil Association



Soil management

Compaction

Compaction is caused by livestock poaching and from inappropriate traffic on land when soils are too wet. This can be difficult to avoid and is made worse by the use of heavy machinery when soils are vulnerable. Compaction causes pans and restricts the ability of roots to penetrate deep into soils, it also reduces water infiltration, causing higher levels of run off. Avoiding poaching and the use of heavy machinery when soils are vulnerable will reduce levels of soil compaction.

Resources:

[Digging the Dirt](#)

[Field Drainage Guide](#)

[Illustrated guide to watercourses by grassland](#)



Living soils

In any agricultural or horticultural system, nutrients are removed from the system when crops and livestock are harvested and sold. Fertility can be built by either growing, or adding organic matter, but in essence this can be likened to supporting the soil micro-organisms to enable them to form associations with the root systems of plants.

[One quarter of all species](#) on Earth live in soils, providing the basis for food production for the other three-quarters. Like all habitats, soils must provide the full range of conditions necessary for these species to survive and thrive. Until now most of us have not managed soils with their biology in mind, the life in soils 'requires the same attention as above-ground biodiversity'. Biodiverse soils have potential benefits beyond healthy crops and higher yields: soil has contributed to a number of recent discoveries, including new forms of [antibiotics](#) and [anti-depressants](#).

Soil is a combination of [minerals, organic matter, air, water and living organisms](#). None can be taken in isolation, it is their balance that is important.



Bacteria

One teaspoon of productive soil can contain 100 million to 1 billion bacteria. Some bacteria convert organic matter into forms useful for plants; others break down pollutants. Some form mutually beneficial partnerships with plants, supplying nitrogen which in turn provide sugar for bacteria.

Fungi

Fungi are important for nutrient cycling, water dynamics, disease suppression and just physically binding soil particles together. Forming long thread like structures called hyphae, they convert hard-to-digest organic material into forms that other organisms can use.

Protozoa

Protozoa are aquatic single-celled animals that live in water filled pores and the film of water that surrounds soil particles. Living in the top 6 inches of soil they consume bacteria, releasing excess nitrogen in a form available to plant roots.

Living soils

Nematodes

Nematodes are microscopic organisms, most of which are beneficial for agriculture. Living in the thin film of moisture that surrounds the soil particles, beneficial nematodes play an important role in decomposing organic matter and therefore the recycling of nutrients.

Earthworms

The feeding and burrowing activity of earthworms incorporates organic matter into the soil promoting decomposition and nutrient cycling. The tunnels they leave behind them provide channels for root growth, water infiltration and gas exchange. A review of nearly 60 different global studies has demonstrated that earthworms can increase yields in the absence of nitrogen fertiliser – by on average 25% [Willem van Groenigen et al (2014) '*Earthworms increase plant production: a meta-analysis*' Scientific Reports]. However, earthworms do not only create good soils, they need good soils to live in. Even slightly degraded soils can affect worm populations.

Arthropods

Arthropods include centipedes, springtails and beetles. They can be grouped as shredders, predators, herbivores, and fungal-feeders, based on their functions in soil. Most soil dwelling arthropods eat fungi, worms, or other arthropods. Root feeders and dead-plant shredders are less abundant. Arthropods mix and introduce air into the soil, shred organic material and control the population of other soil organisms.



Living soils

Molluscs

This is an important and diverse group of invertebrates that include snails and slugs. Many can have an adverse impact on crop production but some also play an important role in the decomposition of dead plants.

Plants

Plants influence soils by exuding chemical secretions into the soil from their roots. For example, buckwheat produces a chemical that increases the availability of phosphorus, an important nutrient. Other plants produce chemicals that stifle the growth of competitors.



Resources:

[Don't forget to feed your soil, Soil Association](#)

[Living Soils, Soil Association](#)

[Soil Food Web](#)



Cover crops & green manures



Cover crops and green manures help the soil but are not broadly considered a cash crop, unless they can be grazed prior to establishing the next crop. Though there is a cost to establishing these beneficial crops, if you make the right choice they will repay any outlay, bringing many benefits to your farm. Here are just a few:

Energy

They capture energy in the form of sunlight that would otherwise hit bare soil and be wasted. Green manure can be seen as a nutrient store for use at a later time.

Diversity

Green manures provide a habitat and food for predators and pollinators as well as providing a habitat for the soil organisms that we don't see.

Protection

Cover crops protect the soil from damage including: drying, which can cause wind erosion; rain damage, that can lead to nutrient leaching and increased disease from rainsplash and run-off; and compaction caused by both vehicle and foot traffic (human or livestock), the effects of which can be eased through added roots and organic matter.

Weed control

A good cover crop will smother weeds, though managing it can create its own challenges.

Author: Ben Raskin, Head of Horticulture at the Soil Association

Cover crops & green manures

Cover crops are usually divided into three broad categories:

Long Term

In many systems, this is the fertility building phase. At bare minimum, a nitrogen fixing plant and a bulky grass are needed. Traditionally a grass clover mix is used, though increasingly innovative seed companies are developing specific mixes for different soils and systems. [Cotswold Grass Seeds](#) are a good example of a business that can help you find the right fertility building seed mix for your farm.

Catch Crops

These are quick growing annual or ephemeral plants that can bulk up to smother weeds and capture soluble nutrients in the soil before they are lost through leaching. Mustard is commonly used as it is cheap and grows well in our climate, though phacelia, buckwheat and fenugreek also offer a good alternative.

Undersowing

Short growing legumes like white clover or yellow trefoil are often used in horticulture, with red also a possibility in arable crops. The key to making this work is timing: the undersown crop should not be established too early, so that it would compete and affect yield, nor too late, so that it would be smothered by the cash crop.

Resources:

[Simon Gardner: Disturbing the soil less and less, GREATSoils](#)

[Sort Out Your Soil, Cotswold Grass Seeds](#)

[Case study: Nathan Richards: Fertility is the focus, Soil Association](#)



Enriching with organic amendments

If the first step on the road to more fertile, balanced soils is growing organic matter, the second is adding fibrous, organic amendments. What you choose for this role will depend on your farm, what your soil needs and what's available.

Soil organic matter (SOM) not only provides a vital food source for soil life but is a well-balanced source of all the nutrients needed by plants and helps improve soil structure. SOM is most often returned to the soil through incorporating grass leys and crop residues, or through the direct application of manures. There are, however, other amendments that you might want to consider:

Author: Caroline Sherrott, Senior Certification Manager



Resources

[Case study: Adrian Hares "Balancing My Soil"](#)

[Managing Manures on Organic Farms, Defra](#)

[Agroforestry and using woodchip to improve soil health](#)

Farmyard manure (FYM)

This can be a way of [adding N, P and K back to your soils](#), after it is lost from the harvested crop. Typical cattle farm yard manure nutrient content at 25% dry matter is 6 kg/T nitrogen (N); 3.5 kg/T phosphorus (P) and 8 Kg/T potassium (K) with as little as 15% of the N available to crops when FYM is applied fresh. Timing of application is critical to minimise losses, with applications through the growing season or outside the window for mineralisation best to avoid leaching. While you'll get a nutrient boost from slurry, you won't get the same SOM-boosting benefits as adding whole FYM or incorporating it. For farms within the Nitrate Sensitive Zone there are [specific limitations](#) on when manures and slurries can be applied.

Enriching with organic amendments



Compost

Composts are a valuable source of stable organic matter, crop available nutrients and active biology. Gross nutrient content is lower than for FYM, but N mineralisation is also greatly reduced and many users report benefits which far outstrip the measured nutrient content of the compost.

Making '[compost tea](#)' from compost is an interesting technique, as in theory it allows you to spread the benefit of the microbiology in compost over a larger area, but does not in itself add organic matter. The [ingredients](#) used in making compost are also key to its quality, with different organisms favoured for different crops.

Woodchip

A [recent field lab](#) found woodchip to be comparable to peat-based compost for horticultural production. If you're weighing up the benefits of trees, take this nutrient-rich by-product into account.

Anaerobic digestate

This is an increasingly available input, with products available as liquids, solids and whole. Research is ongoing into the value of digestate products, with special attention to minimising the loss of N through volatilisation. Essentially the products are similar to the manure produced by ruminants with the process inside the digester very similar to inside the rumen of cattle and sheep. The quantity and crop-availability of the nutrients in digestate will depend on the process input materials, the process itself and any post-treatment manipulation of the digestate such as de-watering. While the total quantity of nutrients will be the same in the whole digestate as in the original input materials, the digestion process changes their crop availability – in particular, the majority of organic (slow release) nitrogen is transformed into (crop-available) ammonium nitrogen.

Certified inputs

Fine-tuning your system so that your soils are perfectly balanced, drained, productive and fed is no easy feat. We know some farmers who've made it their life's work and after decades of time and investment, they still feel like there's something more they could do to improve their soils. The fact is that getting it right takes time, and you've got a business to run. Getting your system, your rotation and your cultivation right will help, but you might still need to give your soil a helping hand.

At the Soil Association, we run a scheme to certify and approve inputs which are suitable for use in an organic system. Some can only be used organically in certain situations, and may require sign-off from your certifier.

Author: Tom Hartley, Senior Certification Officer



Resources:

[Case study: Pete Dollimore: Getting the balance right, Soil Association](#)

[Inputs](#)

[Fertilisers – organic inputs](#)