BETTERRETURNS

AHDB

Improving soils for Better Returns

Manual 3

BEEF & LAMB

Contents

The information in this booklet was compiled by Sue Buckingham (Forward Thinking Farming), Charlie Morgan (GrassMaster), Dr Liz Genever (AHDB Beef & Lamb) and Dr Debbie McConnell (Agri-Food and Biosciences Institute).

AHDB funds an extensive programme of research and knowledge exchange on soil management. AHDB's programme covers soil sampling, soil assessment of texture, pH, nutrient and organic matter content, drainage, cultivations and compaction as well as effects on soil borne diseases. To find out more and to view the latest literature visit **ahdb.org.uk/projects/greatsoils**

Photography: Environment Agency, Germinal and SRUC

Introduction

Soil is an essential natural resource and is the raw material for 99 per cent of land-based food production. On beef and sheep farms, soil condition affects the yield and quality of grass and forage crops, thereby directly influencing livestock performance and enterprise profitability.

Soil is a dynamic mix of minerals, organic matter, air and water, which changes in response to cropping, cultivation, nutrient applications, weather and the activities of soil organisms. Good soil management starts with a soil assessment followed by good management to maintain structure, balanced chemistry and healthy biology.

A spade is the key tool for carrying out soil assessments. Digging a hole and handling the topsoil and subsoil to identify soil type, structure, compaction and earthworm activity, provides essential information to guide future management.

Soil sampling can identify shortfalls and surpluses in key nutrients and measure soil acidity, which when corrected, can improve grassland performance and save farmers money.

Soil management is also part of cross-compliance and other regulations. Soils should be managed to maintain cover and organic matter. It is essential to prevent erosion and runoff for cross-compliance and 'farming rules for water' requirements.

This manual offers useful advice to help improve knowledge and management of farmland soil to safeguard this basic resource and produce healthy crops and livestock while also improving the environment.

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Senior Scientist

Soil type

Soils are formed over thousands of years and reflect geology, past climate, vegetation, landscape, human activity and management.

Healthy, fertile soil is a dynamic living system with physical, chemical and biological properties that promote plant and animal health and maintain environmental quality.

Assessing these three, interdependent features is vital to understanding, maintaining and improving the health of farm soils.

Soil is a complex mix of minerals, water, air and organic matter. A healthy soil contains around 25 per cent air, 25 per cent water, 45 per cent minerals and 5 per cent organic matter. The physical properties of soil vary within and between fields and at different depths.

Knowing the soil type is important because it influences drainage, water and nutrient-holding capacity and susceptibility to erosion. Soil type also affects the ways in which the soil is likely to react to different weather conditions and management practices.

Although soil type cannot be easily changed, knowing which soil type is present helps to determine how to manage the soil, so as to optimise its structure and nutrient supply in grass and forage crops.

For most soils, the soil type is defined by its mineral content and is governed by the percentage of sand, silt and clay particles. In practice, most soils are a mix, eg silty clay.

The UK has 11 mineral soil types (see Figure 1). There are also peaty soils with very high levels of organic matter and moisture content and alkaline chalky soils.

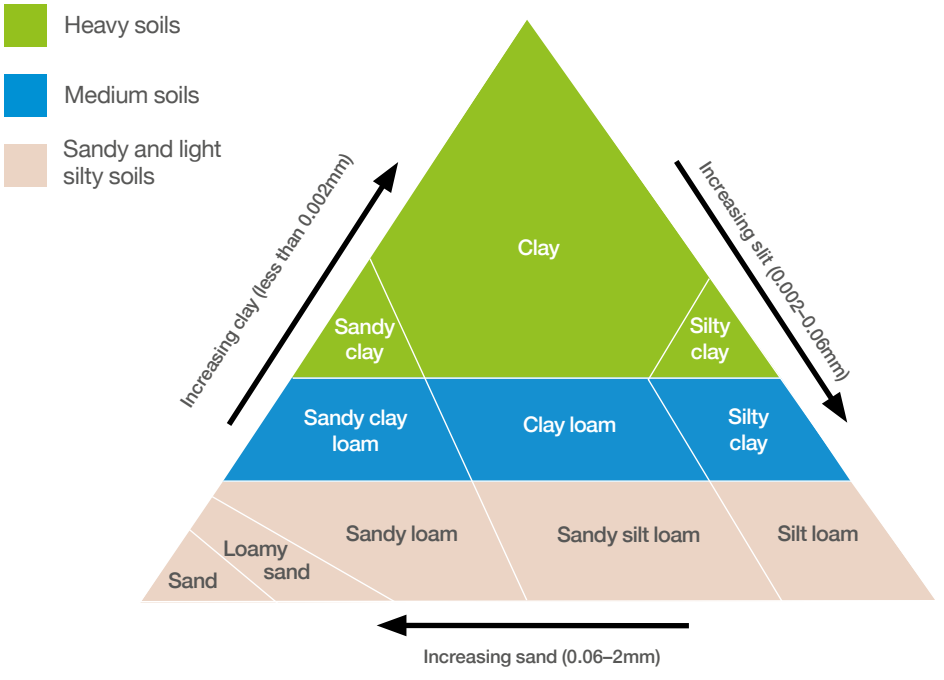
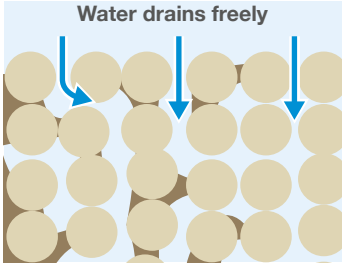


Figure 1. The UK soil texture triangle

Source: Controlling soil erosion (Defra, 2005)

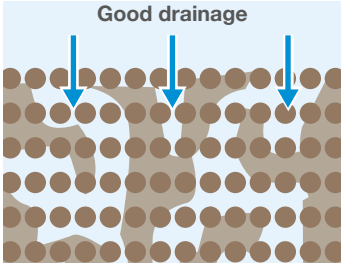
Characteristics of different soils

Sand
Largest soil particle at 0.06–2mm



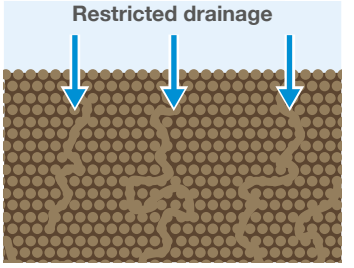
- Large air spaces between particles
- Free circulation of air and good drainage
- Warms up quickly in spring and has a long growing season
- Drought-sensitive, often acidic
- Weak structure so may slump or cap
- Prone to compaction by deep cultivation or harvesting in wet weather
- Can suffer from runoff and erosion by water and wind

Silt
Smaller than sand but bigger than clay at 0.002–0.06mm



- Air spaces and water channels are more restricted than in sandy soils
- Fertile, fairly well-drained and holds more moisture than sandy soils
- Easy to cultivate except in dry conditions, but easily compacted
- Prone to capping so needs careful management
- Damaged when worked or grazed in wet conditions

Clay
Smallest particle at less than 0.002mm



- Restricted air and water movement so can lie wet for long periods
- Contains high levels of nutrients if drainage is adequate
- Easily compacted if poached while wet
- Bakes hard in dry conditions
- Unsuited to ploughing in spring if subsoil remains wet
- May crack in dry or frosty conditions, which can alleviate compaction

Other soil types

Loam
- A mixture of sand, silt and clay particles
- Good water retention and nutrient holding capacity
- Generally easy to work

Peaty soils
- High in organic matter
- Wet and often acidic
- Easily compacted when wet
- Prone to drying and erosion if drained
- Unimproved peat has high biodiversity value, stores carbon dioxide and should be preserved

Chalk
- Also classed as alkaline soil
- Often shallow and free-draining
- Not all nutrients are available to plants because of high soil pH

Soil structure

Structure describes how the sand, silt and clay particles are arranged into clusters known as aggregates. Organic matter and clay particles are the primary binding agents.

Healthy soils have a mixture of large and small air spaces (see page 5). These are important for water, air and nutrient movement, root growth and soil biology. Soil structure is affected by pressure. High stocking density and heavy machinery can squash the soil particles together, particularly when soils are wet, leading to compaction.

It is important to routinely assess soil structure and the Healthy Grassland Soils initiative provides a system for doing this.

Assessing soil texture

Soil texture helps to define soil type. Rub some moist soil between your finger and thumb. Apply water if necessary. Sand feels gritty and soon breaks up when moulded into a ball. Silt feels smooth, silky or floury, while clay feels sticky when wet, looks shiny when smeared and will hold a ball shape.

Soil texture cannot be changed, but knowing it can help with field management planning. Some soil testing laboratories offer a soil texturing service.

Step one: surface assessment

Look at sward quality to identify potentially damaged areas that require further assessment. It is worth looking at a poor part of the field because this helps to prioritise fields for action.

Good quality

- Sward intact
- No poaching
- Few wheelings

Moderate quality

- Surface poached
- Wheelings in places
- More weed species

Poor quality

- Surface capping
- Soil exposed
- Severe poaching
- Poor sward quality

Tips

- When starting out, it is useful to dig in an area where there may be a known problem, eg a gateway, to become familiar with signs of damage to soil structure
- Sample when the topsoil is moist – it is difficult to identify signs of poor soil structure if the soil is too dry or too wet
  - The soil is too dry if the surface is extremely firm and there has been little rainfall over the previous few weeks
  - The soil is too wet if a boot penetrates more than 5cm when walking

Step two: soil extraction

To extract the soil block, cut down on three sides (width and depth about 30cm). Lever the block out, leaving one side undisturbed.

The undisturbed side can be used for assessment while still in the ground, or another block can be dug behind the undisturbed side so it can be removed and assessed.

Lay the block on a plastic sheet or tray.

Step three: soil assessment

Gently open up the soil block like a book to break it up.

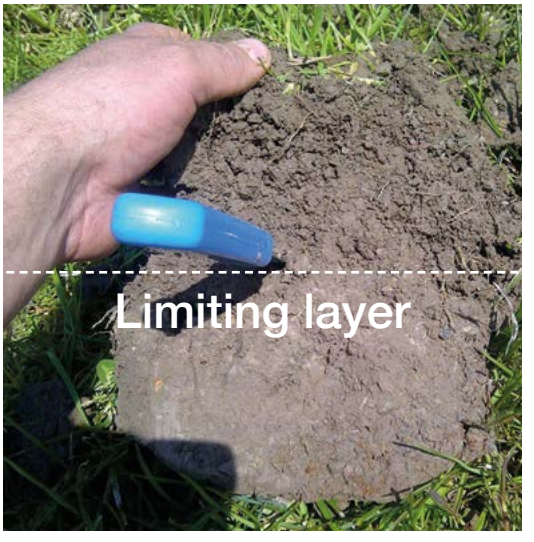
- If the structure is uniform – assess the block as a whole
- If there are two or more horizontal layers of differing structure, identify the layer with the poorest structure (the limiting layer)
- Carry out the rest of the assessment on this limiting layer

The limiting layer is defined as the layer within the soil profile that limits root penetration or water drainage.

The limiting layer is an area of more compacted soil where soil particles have been pushed together, leaving little space for water or air. The depth of the limiting layer helps to identify its cause and determine its remedy.

Moderate over Good

Good over Poor



Soil structure

Step four: soil scoring

Break up the soil into smaller structural units or aggregates (soil lumps).

- Assign a score by matching the soil to the descriptions and photos below
- A score of 1 or 2 is good, a score of 3 is moderate and 4 or 5 is poor and requires management action
- Record the depth of the limiting layer to assess management options

The size and shape of the aggregates are key to soil structure assessment. If the soil only breaks up into large (greater than 10cm) angular aggregates, action is needed.

Score 1 – Crumbly

Structure quality – Aggregates readily crumble with fingers

- Good soil structure
- Highly porous
- Many, well-distributed roots
- Sweet, earthy smell
- Small, rounded aggregates

Management options
Re-assess if there are visible signs of damage in wet conditions or every two years.

Score 2 – Intact

Structure quality – Aggregates easily break apart

- Good soil structure
- Porous
- Good root distribution
- Earthy smell
- Some indication of larger aggregates

Management options
Consider infrastructure changes, eg back-fencing, multiple field entrances or tracks to minimise traffic in marginal weather conditions. Re-assess annually.

Score 3 – Firm

Structure quality – Most aggregates break down

- Adequate soil structure
- Large aggregates, some angular
- Moderate root distribution
- No strong smell
- Less visible pores

Management options
Re-assess in six months and consider aeration options if no improvement.

Score 4 – Compact

Structure quality – Effort needed to break down aggregates

- Large, angular aggregates greater than 5cm across with low pore numbers
- Some red/orange mottling may be present (sign of poor drainage)
- Roots clustered in large pores, worm channels and cracks between aggregates
- May have a sulphur smell (like bad eggs)

Score 5 – Very compact

Structure quality – Aggregates compact, difficult to pull apart

- Very large angular aggregates (greater than 10cm) with very few pores
- Any roots are seen mainly at the surface or clustered down large pores or cracks
- May be grey in colour with red/orange mottling (sign of poor drainage)
- May have a strong sulphur smell (like bad eggs)

Management options for scores 4 and 5
If soil structure is poor at a depth of less than 10cm, use a sward slitter or aerator. If soil structure is poor at a depth of 10cm or more, use a sward lifter or topsoiler. If the sward is poor, consider ploughing or reseeding.

For more information on Healthy Grassland Soils, go to **healthygrasslandsoils.co.uk** where you can find the **Healthy Grassland Soils Pocketbook**

Soil chemistry

Soil chemistry is the study and analysis of the chemical characteristics of soil, which are affected by mineral composition, organic matter, environment and management.

Plant nutrients

Like animals, plants need nutrients to grow. Good nutrient management is a key to farm profitability. If essential nutrients are in short supply, plant health and yield is affected.

A soil test is vital to help identify nutrient availability. A FACTS-accredited adviser should use the results to produce a nutrient management plan that matches nutrient inputs (fertilisers and organic manures) to crop demand. For more information, see the BRP manual **Managing nutrients for Better Returns.**

How to sample grassland soils

It is important to collect a representative soil sample from the field. Poor sampling can give inaccurate results, which can increase costs through unnecessary applications or reduce yields.

How to test

- Twist a gouge or pot corer down to 7.5cm
- Walk the field in a 'W'. Avoid gateways, feeding areas or former muck-heap sites
- Collect 25 plugs of soil in a clean bucket
- Seal a well-mixed subsample in a plastic bag or box and label
- Send to an accredited soil testing laboratory (either directly or via a local co-op, fertiliser merchant or independent company)

For fields that are regularly cut for hay and silage, soil samples should be taken every three or four years because significant levels of nutrients are removed.

For grazed fields that previously had optimum fertility levels, sample the soil every five to six years.

Light, sandy soils, or those in areas with high rainfall, may need sampling every three years.

Ideally, samples should be taken in the same season and at least three months after the last application of manure, fertiliser or lime. Prioritise under performing fields, those that will be reseeded, those that have received a lot of organic manures, such as muck, slurry or digestate, or where perennial ryegrass content is in noticeable decline.

Sample areas of the field that are known to differ separately, eg soil type, previous cropping and nutrient applications. Small areas that vary from the majority of a field should be excluded from the sample.

Soil biology

More than one-quarter of all the living species on earth live in the soil and most are invisible to the naked eye.

Soil organisms are hugely diverse and are critical for a range of soil processes. Soil biology covers all living organisms including earthworms, bacteria, fungi, protozoa and nematodes.

The importance of soil organic matter

Soil organic matter (SOM) provides the energy for soil life. When it breaks down it forms humus, which is crucial in supplying nutrients for crops and creating the right environment for them to grow.

Sandy soils naturally have lower SOM levels than clay soils. Typically, well-managed sandy soils contain SOM levels of 2.5 per cent, while clay soils on livestock farms have more than 6 per cent. Increasing SOM levels can protect soils against compaction.

Actions of soil organisms

- Decompose organic matter including manure and plant residues
- Bind soil particles and stabilise soil structure
- Allow soil to absorb rainfall through an open pore network
- Fix atmospheric nitrogen through symbiosis between rhizobia and legumes
- Transform soil minerals into a plant-available form
- Store and recycle nutrients
- Improve pore network to hold water and support pasture growth through drought

Earthworms

Earthworms are one of the most visible and important soil organisms. They create vertical and horizontal tunnels, break down and recycle organic matter and make nutrients more available for plant growth. In the UK, there are at least 25 species of earthworm and at least 10 of these are common.

You can familiarise yourself with the common species of British earthworm by visiting **www.opalexplore.org/earthwormguide**

Assessing soil health

Earthworm numbers

Earthworm numbers are a good indicator of soil biological health. Count and record the number of earthworms in a moist block of soil in the spring or autumn. Compare the numbers found at the same time each year to see if they are increasing or decreasing.

Soil organic matter

SOM tests are likely to be valuable where levels may be low, eg in sandy soils or land previously used in continuous arable.

Other tests

Tests are available for biological indicators. However, there is currently little evidence to support the routine use of analysis for soil biology.

Compaction

Over 60 per cent of grassland soils in England and Wales show signs of compaction. Compaction is where soil has been squashed into a solid, impermeable layer, either at the surface or within the topsoil. This layer restricts the movement of air, water and nutrients down through the soil profile.

Compaction leads to poor root growth, which in turn stresses the plant and reduces its response to nitrogen. Applying nutrients to compacted soils wastes time and money and can damage the environment because the plant will not be able to fully utilise it.

On compacted soil, the risk of fertiliser runoff increases by up to 60 per cent. In addition, soil erosion and surface water runoff are more likely, which can carry soil sediment and pesticides into watercourses.

Compaction can also cause temporary waterlogging. Wet soils stay colder for longer, reducing the number of available grazing days. They can also make harvesting difficult, which is likely to reduce the quality of the resulting silage. Poaching by livestock is also more likely to occur.

Signs of compaction

- Poor crop yield and quality
- Standing water
- Reddish tinge to grass leaves indicating stress
- Rushes, marsh thistle, creeping buttercup and Yorkshire fog
- Scorch marks from urine patches where urine cannot drain away

Complete an assessment and score the soil using the Healthy Grassland Soils assessment tool available at **healthygrasslandsoils.co.uk**

Some soils under grassland have the capacity to recover when compaction is mild, so it is worth monitoring the soil over a period of several months to see if it improves. Soils can be improved naturally by removing livestock, through clay soils cracking in dry or frosty conditions and by preventing machinery traffic.

Plants with deep roots, such as red clover, lucerne and chicory, can also help improve soil structure, as will earthworm activity and regular application of farmyard manure.

Research has also shown that soils under white clover grass leys have better structure than those under grass only.

If the sward is poor and soil damage is severe with large areas of compaction, consider ploughing and reseeding. Serious poaching, runoff and soil erosion from compacted fields must be dealt with quickly to meet cross-compliance rules and farming rules for water.

Table 1. Compaction type, causes and remedy

Compaction type	Typical cause	Remedy
Surface capping or compaction	Grazing in wet conditions Sheep trampling at high stocking densities Rainfall on new cultivations	Lime or introduce organic matter to encourage earthworm activity to break cap Grass harrow Plough
Compaction (up to 10cm deep)	Cattle trampling Silage and muck-spreading operations – the first wheeling creates 70 per cent of the damage so use tramlines if possible	Surface-slit or aerate Subsoiler or sward lifter Plough
Plough pans (10–15cm deep)	Repeated reseeding at one depth	Sward lifter Mole plough (heavy soils only) Deeper plough just below pan

Always check soil moisture conditions – do not use machinery to remedy compaction in wet conditions or the problem will worsen.

Compaction is strongly linked to machinery use and high stocking density on wet soils. Machinery compaction generally occurs at half the tyre width below the soil surface.

Need to roll?

Roll silage fields only to:

- Push any stones below cutting height
- Level mole hills to avoid soil contamination

If neither of these is a problem then rolling is a waste of time and money. Do not roll severely poached areas

Machinery

- Maintain field drains and ditches to ensure existing draining systems remain effective. See the **AHDB Field Drainage Guide** for more information
- Keep off wet fields, especially within 48 hours of heavy rainfall
- Reduce machine size and total axle loads to avoid excess ground pressure
- Reduce ground pressure by using larger tyres and low inflation pressures
- Create tracks for machinery and control traffic – use tramlines or established wheelings, especially with heavy loads

Livestock poaching

Damage to grass and the underlying soil when it is trampled by livestock in wet conditions is called poaching.

Cattle can leave 10–12cm deep compacted depressions or pockets in the surface of the ground. Water can lie in these pockets and there may be a layer of grey, smelly, unhealthy soil underneath.

These are usually in areas of greatest activity such as gateways or around drinking troughs and feeders.

The destruction reduces grass growth and allows weeds to infiltrate the bare areas.

Rectify compaction as soon as conditions allow, eg by ploughing, subsoiling or sward lifting, to help water penetrate the soil.

Sheep damage grassland differently. They are less likely to break the soil surface, but at high stocking densities they pound the ground as a flock, producing a solid compaction layer around 2–6cm deep over a wide area. However, sheep that are rotationally grazed in winter (All-Grass Wintering) cause less damage because they are only on a small area for a short time.

Avoid

- Poaching near watercourses because of the risk of soil runoff into water and on fields sloping to water. Provide alternative drinking sources, eg drinking troughs and pasture pumps and fence off watercourses
- Feeding livestock near watercourses. Plan winter feeding in advance
- Making vehicle tracks on wet soil that damage soil structure and create pathways for water and soil movement
- Create multiple entry points to fields
- Outwinter on light, free-draining, well-structured soils, away from watercourses
- Use dedicated tracks for machinery and moving stock
- Strip-graze and back-fence
- Move temporary water troughs and feeders regularly or set up a series of troughs and feeders
- Consider placing permanent troughs on concrete bases
- Feed using a mobile snacker system rather than static troughs
- If possible, at harvest, place bales in fields where they will be fed
- Remove livestock from wet fields where possible, particularly when grazing forage crops
- Reduce stocking rates
- Do not drive across fields in wet conditions
- Allow at least two weeks before grazing after slitting or sward-lifting

Optimum soil pH

Correcting the pH of an acidic soil by applying lime improves the yield response of grass to applied nutrients. It also helps soil structure, optimises the availability of soil trace elements, increases earthworm numbers and reduces the risk of nutrient losses to the environment.

Figure 2. pH (acidity) – essential for interactions between nutrients and optimising plant growth

* Ideal pH for continuous grass on mineral soils. Increase pH on mineral soils to 6.2 if occasional barley crops are grown and to pH 6.6 for leafy forage crops and lucerne.

** Ideal pH for continuous grass on peaty soils. Increase pH on peaty soils to 5.5 if occasional barley crops are grown. Peaty soils are unsuitable for leafy forage crops and lucerne.

The amount of lime needed depends on soil type and liming material. There are many liming products available and your choice should be based on neutralising value (NV), fineness of grind and hardness of the parent rock.

- Usually 4–5t/ha (ground limestone NV of 5–55) increases soil pH by 0.4 units
- Apply a maximum of 5t lime/ha in any one season. Split the dressing where more is required
- It takes 9–12 months for pH to increase; re-test after one year to check
- Allow three months after lime applications before applying slurry or urea. Lime increases nitrogen loss through accelerated ammonia volatilisation. If slurry is applied before liming, leave a week before spreading the lime
- Sandy soils need more frequent liming at lower rates because they have reduced capacity for holding lime
- Apply calcium lime only, where soil tests show a magnesium index of 2 or above

Note: Agri-environment scheme prescriptions on wildlife habitat land may restrict the use of lime.

For more information see the BRP manual **Managing nutrients for Better Returns** available at **beefandlamb.ahdb.org.uk**

Soil test results

There are three key figures to examine in a standard soil test.

TOO LOW

Phosphate (P_2O_5)

Essential for:

- Root development, which provides anchorage, early season growth, drought tolerance and allows efficient uptake of nitrogen
- Rapid establishment of new seedlings and is key to survival of clover

1 (0–9mg/l)

Application of manure/slurry/bagged phosphate. Use different products for different situations:

- Slow-release rock phosphates to build up soil levels slowly (cheaper)
- Instantly available phosphates give quicker plant response (more expensive)

Greatest response to phosphate in spring grass.

Potassium (K_2O)

Essential for:

- Transport of nutrients around the plant, including efficient movement from root to leaf
- The efficient uptake of nitrogen and protein production

0 (0–60mg/l)

Application of manure/slurry/bagged potash.

Currently the most expensive nutrient to buy so look for forms that will build up levels cheaply, eg potash in manure is 90 per cent available, with 7.2kg per tonne.

Magnesium (MgO)

Essential for:

- Reducing the risk of staggers in grazing animals

0 (0–25mg/l)

Apply magnesium lime (15 per cent magnesium).

In grassland systems, nitrogen recommendations are based on the level of production required.

Nitrogen (N)

Essential for:

- Grass production
- Conversion of protein into meat and milk

In periods of good growth, 1kg of N will grow between 10–15kg of grass dry matter (DM) in older swards. In newer, high-performing swards (less than 10 years old) the response is typically 15–30kg of grass DM per kilogram of N applied.

The key nutrients can influence how efficiently nitrogen will be used. Moving up from low to ideal soil indices can mean a reduction in the amount of nitrogen required, or lead to an improvement in yield.

Nitrogen can be sourced from many places such as manures, artificial fertilisers or legumes. When nutrient planning, always estimate crop demand by accounting for nutrient losses from taking silage/hay cuts and for those supplied by organic manures.

Other soil tests, such as calculating the base–cation saturation ratio are available. However, no scientific trial results from the UK have shown an economic benefit from adopting advice based on the results.

IDEAL	TOO HIGH
2 (16–25mg/l) **Remember:** If pH is less than 5.5 or greater than 6.5, phosphate is locked up.	**4** (More than 70mg/l) Keep to limits set in manure management plan There is a great risk to the environment because phosphate attaches to soil particles. This causes algal blooms in water, which must be avoided. Applying phosphate when the index is this high is a waste of money.
-2 (121–180mg/l) **+2** (181–240mg/l) **Remember:** Do not apply more than 80–90kg/ha of potash in spring to grazing land to avoid staggers.	**4** (More than 241mg/l) Can cause: • Staggers in livestock • 'Luxury' uptake in silage crops, which leads to lodging. Excess potash is not harmful to the environment
2 (51–100mg/l)	**4** (More than 100mg/l) Reduces potash and N efficiency. High magnesium soils are difficult to cultivate because they form large blocks that are hard to break down. Increased risk of staggers.
Remember: Too much N can cause high ammonia levels in silage, leading to reduced intakes and potential pollution problems.	N applied above crop demand will be readily lost to air and water, impacting sensitive habitats and drinking water quality. Lost N wastes money.

For more information, see the **AHDB Nutrient Management Guide (RB209)** at **ahdb.org.uk/rb209**

Tried & Tested nutrient management plan tools and information are available in printed and electronic versions at **www.nutrientmanagement.org.uk**

MANNER NPK practical software, which provides a quick estimate of crop available nitrogen, phosphate and potash supply from applications of organic manure, is available at **dairy.ahdb.org.uk/technical-information**

The impact of poor soil management

Yield

A young, well-managed ley can produce more than 12t DM/ha per year when grazed and more than 14t DM/ha per year under a cutting regime. Permanent pasture can produce more than 9–10t DM/ha per year. These levels of production can only be sustained with no compaction, adequate nutrient reserves and appropriate management.

Compaction by animals or tractors reduces yield by up to 2t/ha. Yield reduction, combined with poor nitrogen recovery and high water retention that delays turnout, has been shown to cost in excess of £250 per ha in lost sward productivity and utilisation.

Quality

Poor soil nutrient content and condition encourages competition from indigenous and less productive grasses. These are less digestible and contain lower levels of energy and protein, thus reducing feed quality, animal intake and performance.

With good soil conditions and excellent grazing management of a high-quality perennial ryegrass/clover sward, a beef animal can gain 1.2kg/day and a lamb 300g/day. However, many beef animals generally only gain 0.6kg/day and lambs only 170g/day off pasture.

The need to reseed more frequently to replace productive grasses lost because of poor soil management costs up to £375/ha for ploughing and reseeding with contractors.

Invest in soil inputs

Sheep research at Bronydd Mawr in mid-Wales during the 1990s and 2000s demonstrated the importance of investing in soils and nutrients for better returns. Plots were grazed by yearling ewes and single lambs from April to August, then ewes alone to November.

Table 2. Summary of treatments and the resulting stocking rate

Treatment	Nutrients applied	Stocking rate (ewes/ha)
1	Lime, nitrogen, phosphate, potash	30
2	Lime, phosphate, potash	25
3	Lime only	15
4	No nutrient input	7

Results

- Increased perennial ryegrass and clover in Treatment 2
- Much shorter grazing season in Treatment 4
- Replacement ewe lambs from Treatment 4 were 4kg lighter than those from Treatments 1 and 2
- Treatments 1 and 2 were commercially viable

The impact of grassland compaction

AHDB Dairy funded work to assess the impact of compaction on grassland productivity. There were two locations, Scotland's Rural College (SRUC) in Dumfries and Harper Adams University in Shropshire.

Grass plots were established from the autumn of 2011 and plots with no compaction were used as the control. The other two treatments were tractor compaction or trampling compaction.

The compaction occurred in the winter of 2011. Grass yield, quality and soil structure were measured.

Figure 2 shows that compaction increases the bulk density of the soil, which means fewer air spaces within the soil. The impact was greatest with tractor compaction. The bulk density of the control plots reduced over time, meaning that the structure improved.

Figure 3 shows the proportion of the pore space filled with water was highest in the plots that were driven on. The soil did not drain as well as in the control plots. The dramatic drop in July coincided with a dry spell, so the number of water-filled pore spaces fell. However, the problems returned when it rained.

Figure 4 shows that yield of the first cut was affected by compaction – grass DM yield was reduced by 14 per cent and 22 per cent respectively.

The suggested cost of compaction can be seen in Table 3.

Table 3. The potential impact of compaction for dairy farms

Loss of yield (10–20%)	£70–200 per ha
Nutrient loss (30–40%)	£120–160 per ha
Reduced grazing days (5–10 days)	£530–1,060 per ha

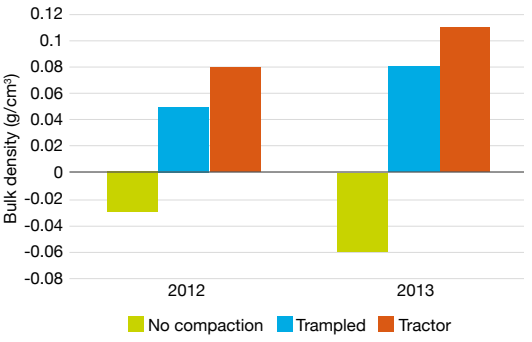


Figure 2. The impact of compaction on change in soil bulk density at 0–10cm at SRUC

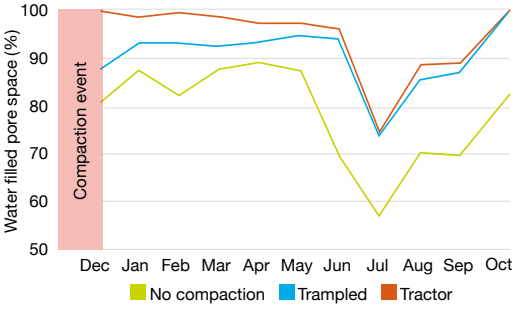


Figure 3. The impact of compaction on soil water-filled pore space at 0–10cm at SRUC

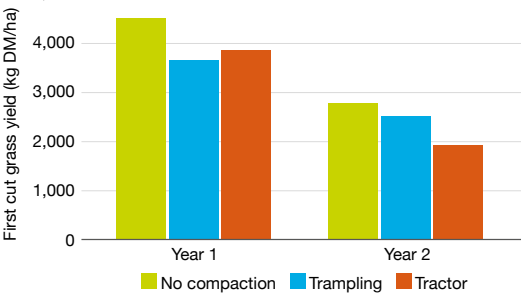


Figure 4. The impact of compaction on first-cut grass yield at SRUC

Managing soils for cross-compliance

As part of cross-compliance, soil protection standards are prescribed for the Basic Payment Scheme to keep farmland in good agricultural and environmental condition (GAEC).

Defra's objectives are to improve soil health and agricultural potential and to reduce soil loss and negative impact on the environment. Recent changes to the cross-compliance rules include maintaining minimum soil cover and soil organic matter and limiting erosion.

Livestock farmers must carefully manage their soils to meet the requirements.

High-risk activity for grassland soils:

- Silage making with loaded trailers
- Spreading manures and slurry in wet conditions
- Grazing when the soil is too wet, particularly when strip grazing
- Outwintering
- Reseeding grassland
- Static feeders or troughs
- Overgrazing with loss of vegetation cover
- Grazing and harvesting fodder crops on heavy soil and sloping ground
- Late-harvested maize stubbles

For more information, please see the below resources:

Cross-compliance: GAEC 4, 5 and 6 relate directly to soils.

GAEC 4: Minimum soil cover. Protection of soil with a minimum soil cover unless there is an agronomic justification for not doing so, or where establishing a cover would conflict with GAEC 5.

GAEC 5: Minimum land management to limit erosion. Site-specific management to limit soil and bankside erosion.

GAEC 6: Maintenance of soil organic matter level. Use of appropriate land management practices to maintain soil organic matter.

Search for cross compliance: soil protection standards' at **www.gov.uk**

Also see the Rural Payments Agency (RPA) website: **www.gov.uk/government/organisations/rural-payments-agency**

Farming Advice Service: email **advice@farmingadviceservice.org.uk** or telephone: 0345 345 1302 (Monday to Friday, 8am to 6pm).

Search for Code of Good Agricultural Practice for Farmers, Growers and Land Managers: Protecting our Water, Soil and Air at **www.gov.uk** for more details.

Farming rules for water

Although not part of the cross-compliance, the 'farming rules for water' include requirements for farmers to protect soil. There is a requirement for regular soil testing, prevention of significant soil erosion, runoff and protecting water from erosion due to poaching by livestock, including around feeders.

See gov.uk/defra/farmingrulesforwater for full details

Managing soils under forage crops

Brassicas and fodder beet can provide nutritious, cost-effective feeds for beef cattle and sheep.

However, there is a risk of soil damage when establishing the crop and harvesting in wet conditions or grazing in situ. Runoff erosion and poaching can be minimised by careful field selection and feeding management. Also use buffers and fenced-off grass strips to protect water bodies from soil runoff.

Pre-drilling

The heavier the soil, the more care is needed to avoid damage. Consider reduced tillage techniques for establishment; for example, direct drilling brassicas into a sprayed-off grass sward, which provides a 'base' to the crop. This reduces soil damage compared to a crop established after ploughing.

Identify appropriate fields:

✓ Sandy soils	✗ Near watercourse
✓ Good drainage	✗ Heavy clay
✓ Gentle slopes	✗ Steep slopes

Pre-grazing

Organise feed fences to provide maximum frontage and a narrow strip of accessible fodder. This ensures the foot pressure of the stock is spread over the field rather than concentrated in one area.

If the field has steep areas, start grazing the crop across the slope at the top, so any runoff is trapped by the standing crop.

Erect a back fence behind the grazing strip but provide a run-back area.

Avoid driving vehicles in the field during winter by planning how many bales of silage will be needed to last the winter and put these out in the summer.

Install several water tanks in the field to reduce poaching.

Post-grazing

Where necessary, cultivate as soon as conditions allow to remove wheelings and compaction. Following harvest, check for soil damage and remedy any problems. Rough-plough sandy and silty soils following harvest to produce a cloddy, coarse surface that is less likely to cap. Sow the next crop within 10 days of cultivating and establish ground cover as quickly as possible.

For more information see the BRP manual **Using brassicas for Better Returns**, available at **beefandlamb.ahdb.org.uk**

Managing soils under forage maize

Growing maize can cause soil damage at sowing and harvest. Ground cover is slow to develop after drilling in spring, leaving the surface susceptible to soil erosion.

Harvesting in autumn can lead to soil structure damage because of heavy trafficking. The bare ground left is open to erosion and soil wash unless managed correctly. A study in the South West of England showed that soils under maize and other late-harvested crops were the most damaged, with 75 per cent showing some degradation.

Pre-drilling

Planning

Decide if the area is suitable for growing and harvesting maize. The best locations are at low altitude, experience high temperatures during summer and have medium-textured soils. Avoid marginal areas and fields with high erosion risk. Sow varieties with appropriate maturity dates for the location. Consider under-row or inter-row sowing a grass cover crop and the use of plastic film.

Whole-crop cereal can provide a cost-effective alternative to maize silage in marginal areas.

Ensure there are adequate buffer strips between the crop and any water sources. Choose the correct cultivation method for soil type; minimal cultivation may be appropriate on well-structured soils. Carry out cultivations in dry weather; aim for at least one full day of dry weather after cultivating to help stabilise the soil. Drill across the slope or use double headlands. Sow early with early maturing varieties to plan earlier harvest.

Manure and fertiliser applications

Check soil nutrient status and complete a field nutrient management plan. Apply organic manures or fertilisers to meet crop needs. Ensure Nitrate Vulnerable Zone (NVZ) regulations are met when spreading organic manures. Wet slurry applied to maize stubbles can reduce water infiltration if it dries and seals the soil surface.

Harvest

Harvest across the slope where possible, using tramlines and fixed trackways to reduce the area of field trafficked.

Avoid harvesting when soils are wet to reduce compaction. Consider re-surfacing gateways with hardcore, concrete or temporary heavy-duty plastic matting. This will prevent soil damage, avoid mud getting onto roads and stop soil runoff into watercourses.

Post-harvest

Sloping headlands should be subsoiled and cultivated as soon as possible after harvest.

If the maize crop was not under-sown to grass, establish the following crop or cover crop, or remove compaction and create a rough surface by ploughing, chisel ploughing or subsoiling, as soon possible when land is suitably dry.

For more information see the BRP manual **Growing and feeding maize silage for Better Returns**, available at **beefandlamb.ahdb.org.uk**

Soil management advice and support

Countryside Stewardship

Countryside Stewardship includes funding for soil and water management options and capital grants through the Mid Tier application process.

For more information search 'Countryside Stewardship' at **www.defra.gov.uk**

Environment Agency

The Environment Agency (EA) is responsible for the protection of the environment includes flood risk management, pollution, water quality and climate change.

The Environment Agency is regulator for the 'farming rules for water' and carries out some cross-compliance inspections. Find out more at **gov.uk/environmental-agency**

Campaign for the Farmed Environment

Campaign for the Farmed Environment (CFE) is a partnership supported by many organisations that are committed to both agriculture and the environment. It provides advice and training to encourage voluntary management that benefits the environment, while ensuring efficient and profitable food production.

Catchment Sensitive Farming

Catchment Sensitive Farming (CSF) offers free training, advice and support to farmers in high-priority water quality areas targeted by Countryside Stewardship.

CSF is a joint project between Natural England, the Environment Agency and Defra, which aims to tackle diffuse water pollution from agriculture to meet the objectives of the Water Framework Directive (WFD).

CSF encourages best practice to:

- Improve soil structure to maximise infiltration of rainfall and minimise soil erosion and runoff
- Deal with soil compaction and waterlogging
- Protect water from faecal contamination and pesticides, eg by watercourse fencing and buffer strips
- Improve efficiency of manure and fertiliser use and minimise nutrient losses
- Avoid soil damage from overstocking or overgrazing

For more information on CSF visit **www.defra.gov.uk**

A clear solution for farmers
CATCHMENT SENSITIVE FARMING

AHDB funds an extensive programme of research and knowledge exchange on soil management. There is practical information on soil management, as well as an overview of ongoing and knowledge exchange, available at ahdb.org.uk/projects/greatsoils

Beef and sheep BRP Manuals

Manual 1	Improving pasture for Better Returns
Manual 2	Assessing the business for Better Returns
Manual 3	Improving soils for Better Returns
Manual 4	Managing clover for Better Returns
Manual 5	Making grass silage for Better Returns
Manual 6	Using brassicas for Better Returns
Manual 7	Managing nutrients for Better Returns
Manual 8	Planning grazing strategies for Better Returns
Manual 9	Minimising carcase losses for Better Returns
Manual 10	Growing and feeding maize silage for Better Returns
Manual 11	Using medicines correctly for Better Returns

See the AHDB Beef & Lamb website **beefandlamb.ahdb.org.uk** for the full list of Better Returns Programme publications for beef and sheep producers.

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