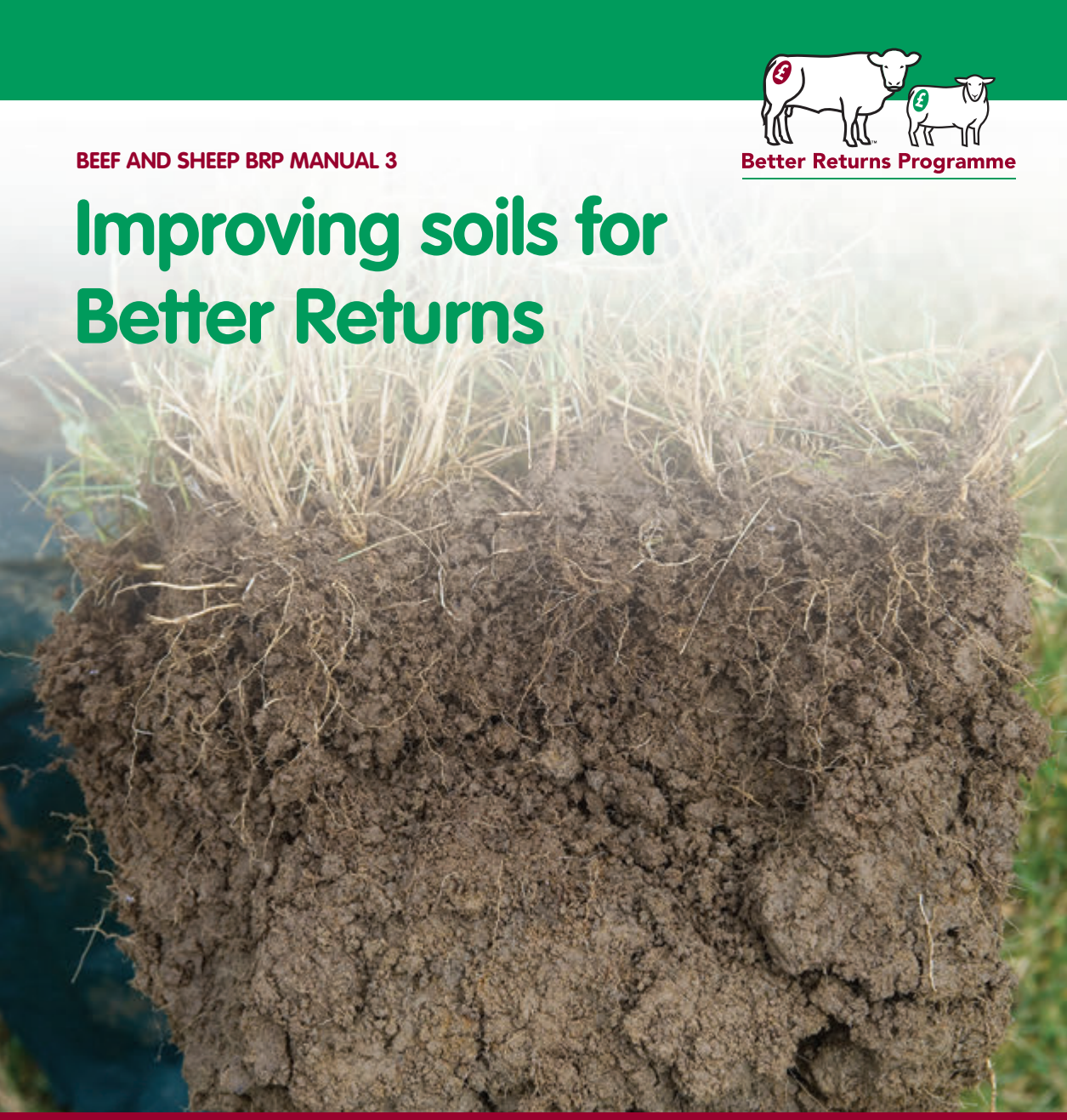
BEEF AND SHEEP BRP MANUAL 3

Better Returns Programme

Improving soils for Better Returns



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

Illustrations: Tebbit Design

Photography: Environment Agency

For more information contact:

Better Returns Programme
AHDB Beef & Lamb
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel: 024 7647 8834
Email: brp@ahdb.org.uk
beefandlamb.ahdb.org.uk

AHDB Beef & Lamb is a division of the Agriculture and Horticulture Development Board (AHDB).

This publication is available from our website at beefandlamb.ahdb.org.uk.

Any enquiries related to this publication should be sent to us at AHDB Beef & Lamb, Stoneleigh Park, Kenilworth, Warwickshire CV8 2TL.

Better Returns Programme

Contents

Soil is an essential natural resource and is the raw material for 99% of land-based food production. The condition of soil on beef and sheep farms directly influences the yield and quality of grass and forage crops, 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 assessment and then managing it to maintain good structure, balanced chemistry and healthy biology.

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

Correct 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. Managing soils to maintain soil cover and organic matter and prevent erosion and run off, are key to meeting Cross Compliance requirements.

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

Dr Liz Genever

AHDB Beef & Lamb
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, inter-dependant 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 will contain around 25% air, 25% water, 45% minerals and 5% organic matter. The physical properties of soil vary within and between fields and at different depths.

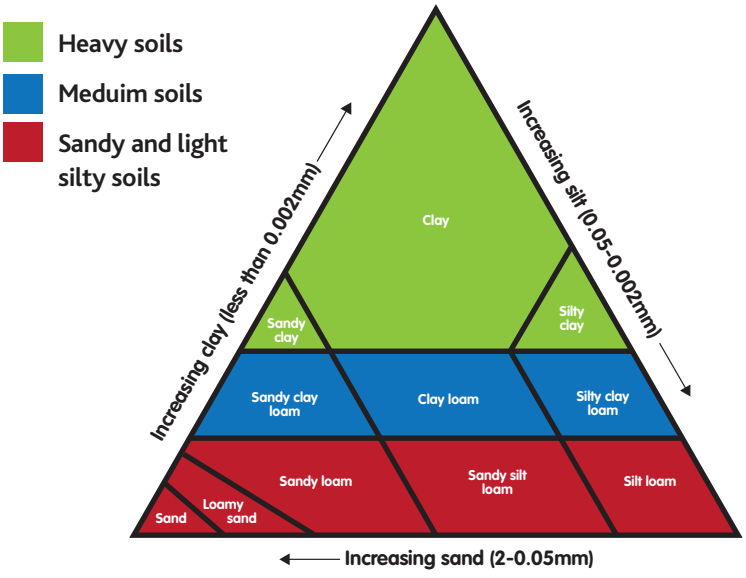
Knowing the soil type is important as it influences drainage, water and nutrient holding capacity and susceptibility to erosion. It also affects how the soil is likely to react to different weather conditions and management practices.

Although soil type cannot be changed easily, identifying it helps determine how to manage soils to optimise structure and nutrient supply in grass and forage crops.

For most soils the mineral content defines the soil type, which 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. In addition there are peaty soils with very high organic matter and moisture content and alkaline chalky soils.

Figure 1: The UK soil texture triangle

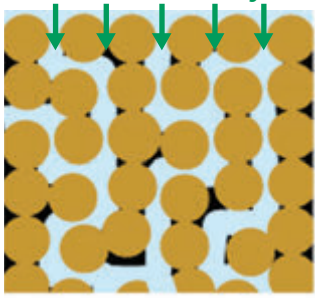


Source: Controlling soil erosion (Defra, 2005)

Characteristics of different soils

Sand
Largest soil particle at 0.05-2mm

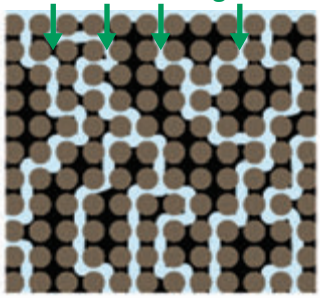
Water drains freely



- Large air-spaces between particles
- Free circulation of air and good drainage
- Warm up quickly in spring and have 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 run-off and erosion by water and wind

Silt
Smaller than sand but bigger than clay at 0.002-0.05mm

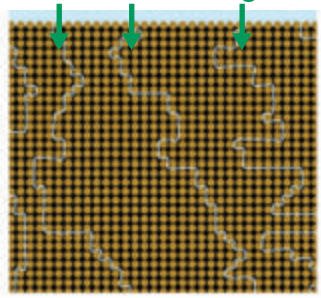
Good drainage



- Air spaces and water channels 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 drainage



- Restricted air and water movement, so can lie wet for long periods
- Contains high level 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 mix of sand, silt and clay particles. Generally more easily worked, with good water retention and nutrient holding capacity.

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 not be improved.

Chalk

- Also classed as alkaline soil
- Often shallow and free-draining
- Nutrients are not all available to plants due to high pH of the soil

Assessing soil texture

Soil texture helps define soil type.

Rub some moist soil between finger and thumb. Apply water if necessary. Sand feels gritty and when molded into a ball soon breaks up. 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 helps plan field management. A soil texturing service is offered by some soil testing laboratories.

For more information on Healthy Grassland Soils go to **healthygrasslandsoils.co.uk**

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 mix of large and small air spaces. 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.

Step one: Surface assessment

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

Good
- Sward intact
- No poaching
- Few wheelings

Moderate
- Surface poached
- Wheelings in places
- More weed species

Poor
- 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. If the soil is too dry or too wet it is difficult to distinguish signs of poor soil structure
  - Soil is too dry if the surface is extremely firm and there has been little rainfall over the previous few weeks
  - 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.

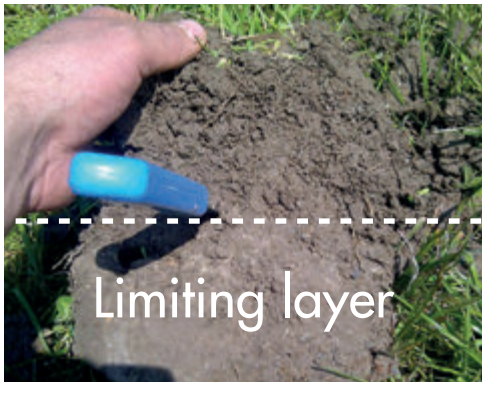
- If the structure is uniform – assess the block as a whole
- If there are two or more horizontal layers of differing structure, identify the layer with the poorest structure
- Carry out the rest of the assessment on this limiting layer

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

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

Moderate over Good

Good over Poor



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 depth of limiting layer to assess management options

The size and shape of the aggregates are key to soil structure assessment. If the soil is only breaking 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 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 entrance 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 sulphur smell like bad eggs

Management options

Consider use of sward slitter or aerator if poor soil structure at a depth of less than 10cm, or a sward lifter or top-soiler if poor soil structure is deeper than 10cm. If sward is poor, consider ploughing and re-seeding.

Score 5 – Very compact

Structure quality – Aggregates compact, difficult to pull apart and are platy

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

Management options

Use a sward slitter or aerator if poor soil structure at a depth of less than 10cm, or a sward lifter or top-soiler if poor soil structure is deeper than 10cm. If sward is poor, consider ploughing or re-seeding.

For more information on Healthy Grassland Soils go to **healthygrasslandsoils.co.uk** and find the **Healthy Grassland Soils Pocketbook** in the Nutrition and Forage section of the Better Returns Programme website (**beefandlamb.ahdb.org.uk**). Or request a copy by calling **024 7647 8834**.

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 one of the keys to farm profitability. If essential nutrients are in short supply, plant health and yield will be affected.

A soil test is essential to help identify nutrient availability. The results should be used to produce a nutrient management plan to match nutrient inputs (fertilisers and organic manures) to crop demand. This means that nutrient use is tailored for optimum uptake and yield minimising nutrient losses to the environment. Nutrient planning should be provided by a FACTS nutrient management planning accredited adviser.

See Beef and Sheep BRP Manual 7 **Managing nutrients for Better Returns** for more information.

How to sample grassland soils

It is important to take time to collect a representative soil sample from the field. Poor sampling can lead to 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 sub sample in a plastic bag or box and label
- Send to an accredited soil testing laboratory (either direct to the laboratory or via a local co-op, fertiliser merchant or independent company)

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

For fields that are grazed and historically have optimum fertility levels, soil sampling every five to eight years should be appropriate.

Ideally samples should be taken in the same season and at least two months after the last application of manure, fertiliser or lime. Prioritise fields that underperform, are going to be re-seeded, that have received a lot of organic manures, such as muck, slurry or digestate, or where perennial ryegrass content is noticeably declining.

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

Soil biology

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

In grassland soils, the soil life below ground often weighs ten times more than the grazing livestock on the surface. Soil organisms are hugely diverse and play a range of critical roles in 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 plays a crucial role in supplying nutrients for crops and creating a good environment in which they can grow.

Sandy soils naturally have lower SOM levels than clay soils. Typically well-managed sandy soils will contain SOM levels of 2.5%, while clay soils on livestock farms have more than 6%. 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 and at least ten of these are common.

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 numbers are increasing or decreasing.

Soil organic matter
Soil organic matter tests are likely to be valuable where SOM may be low, eg sandy soils, land previously in continuous arable.

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

Compaction

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

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

On compacted soil, the risk of fertiliser run-off increases by up to 60%. In addition soil erosion and surface water run-off 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.

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 can not drain away

Complete an assessment and score the soil using the Healthy Grassland Soils assessment tool (**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. Natural improvements can result from removing livestock, clay soils cracking in dry or frosty conditions and by stopping machinery trafficking.

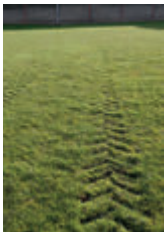
Plants with deep roots, eg red clover, lucerne and chicory, can also help improve soil structure, as will earthworm activity and regular application of farmyard manure.

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

If the sward is poor and soil damage is severe with large areas of compaction, consider ploughing and re-seeding. Serious poaching, run-off and soil erosion from compacted fields must be dealt with quickly to meet Cross Compliance rules.

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 muckspreading operations – the first wheeling creates 70% of the damage so use tramlines if possible	• Surface slit or aerate • Subsoiler or sward lifter • Plough
Plough pans (10-15cm deep)	• Repeated re-seeding 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 get worse.



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 – 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 **Drainage Guide** for more information
- Keep off wet fields, especially within 48 hours of heavy rainfall
- Lessen ground pressure by reducing machine size and total axle loads
- Reduce ground pressure; use larger tyres and low inflation pressures
- Control machinery trafficking – use tramlines or established wheelings, especially with heavy loads, eg silage trailers
- Create tracks for machinery

Livestock poaching

Poaching is the name for damage done to grass and the underlying soil when it is trampled by livestock in wet conditions.

Cattle can leave compacted depressions or pockets in the surface of the ground 10-12cm deep in which water can lie. Beneath may be a grey, smelly, unhealthy layer of soil.

These are usually in areas of greatest activity, in 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 over a wide area at 2-6cm deep.

Avoid

- Poaching near watercourses because of the risk of soil run-off 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

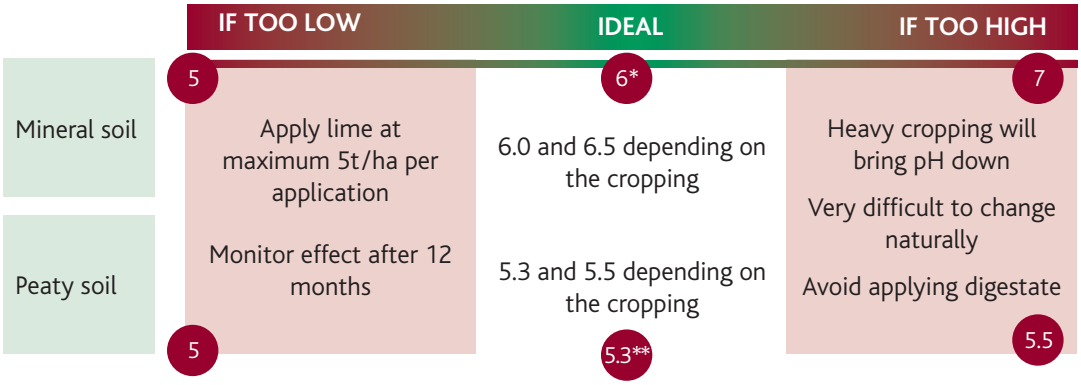
How to prevent poaching

- Create multiple entry points to fields
- Outwinter only 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
- For permanent troughs, consider placing them on concrete bases
- Feed using a mobile snacker system rather than static troughs
- 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 and sward lifting

Optimum soil pH

Correcting the pH of an acid soil by applying lime will improve the yield response of grass to applied nutrients. It will also help soil structure, optimise the availability of soil trace elements, increase earthworm numbers and reduce the risk of nutrient losses to the environment.

pH (Acidity) – Essential for interaction of 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 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 and 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 50-55) will increase 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 nine to 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, as 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.

See **Managing nutrients for Better Returns** manual for more information on lime application.

Available to download from the BRP literature section of **beefandlamb.ahdb.org.uk** or email **brp@ahdb.org.uk** or call **024 7647 8834** to request a free copy.

Soil test results

There are three key figures to examine in a standard soil test, phosphate, potassium and magnesium.

P (Phosphate, P_2O_5)

Essential for:

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

IF TOO LOW

1 (0-9 mg/l)

Application of manure/slurry/bagged phosphate.

Use different products for different situations:

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

Greatest response to phosphate in spring grass.

K (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 (0-60 mg/l)

Application of manure/slurry/bagged potash.

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

Mg (Magnesium, MgO)

Essential for:

- Reducing the risk of staggers in grazing animals

0 (0-25 mg/l)

Apply magnesium lime (15% magnesium).

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

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

N (Nitrogen)

Essential for:

- Grass production
- Conversion of protein into meat and milk

Generally, 1kg of N will grow between 10-15kg of grass DM in older sswards. In newer, high performing swards (less than ten years old) the response is typically15-30kg of grass DM per kg N applied.

Other soil tests, such as 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	IF TOO HIGH
2 (16-25 mg/l)	4 (More than 70 mg/l)
Remember: If pH is less than 5.5 or greater than 6.5, phosphate is locked up.	Keep to limits set in manure management plan. There is a huge risk to the environment, as phosphate attaches to soil particles causing algal bloom in water which must be avoided. Applying phosphate when the index is this high is a waste of money.
-2 (121-180 mg/l) +2 (181-240 mg/l)	4 (More than 241 mg/l)
Remember: Do not apply more than 80-90kg/ha of potash in spring to grazing land to avoid staggers.	Can cause: • Staggers in livestock • 'Luxury' uptake in silage crops which leads to lodging Excess potash is not harmful to the environment.
2 (51-100 mg/l)	4 (More than 100 mg/l)
	Reduces potash and N efficiency. High magnesium soils are difficult to cultivate as it creates big blocks that are hard to break down. Increased risk of staggers.

Nitrogen can be sourced from many places, eg manures, artificial, fertiliser 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.

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 will waste money.

For more information

Crop Nutrient Management Manual (formerly known as RB209) at **ahdb.org.uk/cropnutrition**

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

MANNER NPK practical software that provides a quick estimate of crop available nitrogen, phosphate and potash supply from applications of organic manure at **ahdb.org.uk/cropnutrition**

The impact of poor soil management

Yield

A young well-managed ley is capable of producing 12t DM/ha per year when grazed and up to 14t DM/ha per year under a cutting regime. Permanent pasture can produce 9-10t DM/ha per year. These levels of production can only be sustained in soils that have no compaction, adequate nutrient reserves and are appropriately managed.

Compaction from animals or tractors has been shown to reduce yield by up to 2t/ha. Yield reduction, combined with poor nitrogen recovery and high water retention, which delays turnout, has been shown to cost in excess of £250/ha in lost sward productivity and utilisation. In addition it can increase reliance on bought-in feeds, reducing self-sufficiency and financial returns.

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. This reduces feed quality, animal intake and performance.

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

More frequent re-seeding to replace productive grasses lost due to poor soil management, costs up to £350-500/ha for ploughing and re-seeding 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 1: Summary of the 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 has funded work on assessing the impact of compaction on grassland productivity. There were two locations, 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 happened 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 that there are fewer air spaces within the soil. The impact was the greatest for the plots that were run over by the tractor. It also shows that the bulk density of the no compaction plots reduced over time, which meant that the structure was improving.

Figure 3 shows that proportion of the pore space that was filled with water was the highest for the plots that were driven on. This means the soil was not draining as well as the control plots. The dramatic drop in July coincided with a dry spell, so the number of water filled pore spaces fell. However, it can be clearly seen that once it rained, the problems came back.

Figure 4 shows that yield of the first cut was affected by compaction, with trampling and tractor compaction reducing grass DM yield by 14% and 22% respectively.

The suggested cost of compaction can be seen in Table 2.

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

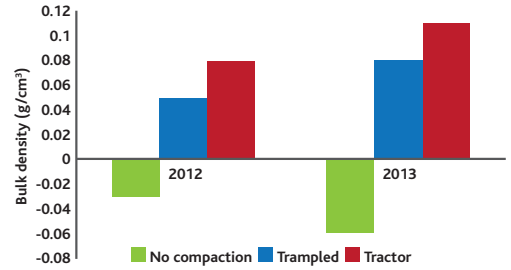


Figure 3: The impact of compaction on soil water filled pore space at 0-10cm at SRUC

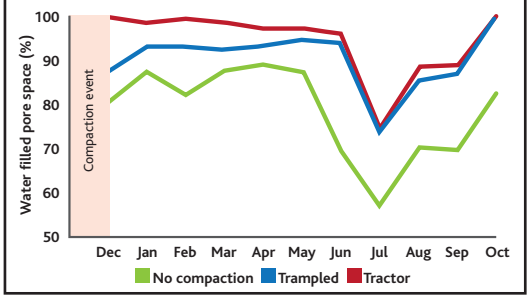


Figure 4: The impact of compaction on first cut grass yield at SRUC

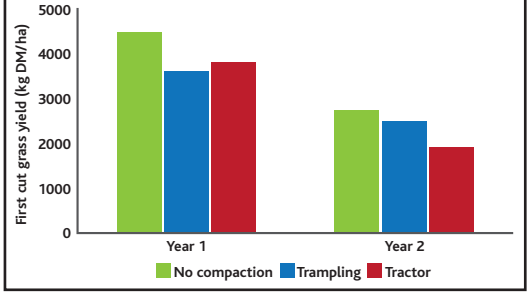


Table 2: The potential impact of compaction for dairy farms

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 100 cows**

Managing soils for cross compliance

Soil Protection standards are prescribed for the Basic Payment Scheme to keep farmland in good agricultural and environmental condition (GAEC) as part of Cross Compliance.

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 producers need to manage their soils carefully 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
- Out-wintering
- Re-seeding 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

More info:

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 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.

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. Minimise run-off erosion and poaching by careful field selection and feeding management. Also use buffers and fenced-off grass strips to protect water bodies from soil run-off.

Pre-drilling

Identify appropriate fields, eg

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

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 that is established after ploughing.

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 run-off will be trapped by the standing crop.

Erect a back fence behind the grazing strip.

Avoid vehicles travelling in the field during winter by putting bales of silage, hay or straw out in the summer. Plan how many bales will be required to last the winter.

Install a number of 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 ten days of cultivating and establish ground cover as quickly as possible.

More info:

AHDB Joint BRP Manual 6 **Using brassicas for Better Returns**. Available to download from the BRP literature section of **beefandlamb.ahdb.org.uk** or email **brp@ahdb.org.uk** or call **024 7647 8834** to request a free copy.

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 due to heavy trafficking. The bare ground left is open to erosion and soil wash unless managed correctly. A study of soils in the South West of England showed that soils under maize and other late harvested crops were the most damaged, with 75% 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 date for location. Consider under- 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 the soil stabilise. 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 wherever 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 run-off 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.

More info:

The Maize Growers Association **www.maizegrowersassociation.co.uk**

AHDB Joint BRP Manual 10 **Growing and feeding maize silage for Better Returns**, available to view at **beefandlamb.ahdb.org.uk**

Soil management advice and support

Countryside Stewardship

Countryside Stewardship replaced Entry Level Stewardship (ELS), Organic ELS (OELS), Upland ELS (UELS) and England Woodland Grant Scheme in 2015. Countryside Stewardship and the Catchment Sensitive Farming Capital Grant Scheme offers capital grants for a range of investments which have the potential to improve soil and water quality.

More info:
Search Countryside Stewardship
www.defra.gov.uk

Environment Agency

The Environment Agency (EA) is responsible for environment regulation of major industries and agriculture, flood risk management, navigation, fisheries, ecology, water quality and resources and climate change.

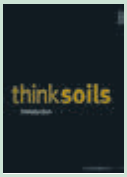
A Soils Strategy launched in 2007, identified the roles and responsibilities of the EA for soil, setting out priorities and action to be taken using regulation, advice, incentives and partnerships.

Campaign for the Farmed Environment

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

See **www.cfeonline.org.uk/campaign-themes/soils/**

More info:
Environment Agency at
www.environment-agency.gov.uk
thinksoils information line:
0870 8506 506



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 (**www.defra.gov.uk**).

CSF is a joint project between Natural England, 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 manures and fertiliser use and minimise nutrient losses
- Avoid soil damage from overstocking or overgrazing

Environment Agency
Department for Environment Food & Rural Affairs
A clear solution for farmers
CATCHMENT SENSITIVE FARMING
NATURAL ENGLAND

More info:
Catchment Sensitive Farming
www.gov.uk/guidance/catchment-sensitive-farming-reduce-agricultural-water-pollution#countryside-stewardship
www.defra.gov.uk

Other BRP publications available

Joint Beef and Sheep BRP

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

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

For more information contact:
Better Returns Programme
AHDB Beef & Lamb
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel: 024 7647 8834
Email: brp@ahdb.org.uk
beefandlamb.ahdb.org.uk

AHDB Beef & Lamb is a division of the Agriculture and Horticulture Development Board (AHDB)

AHDB
BEEF & LAMB