Soil smart and nutrient wise - a guide for on-farm practice

BGS

Welcome

The British Grassland Society

The British Grassland Society (BGS) is a charity that was established to bring together all sectors of the agricultural industry, farmers, educators, researchers and the allied industries that have an interest in grass and forage production and utilisation. Many of the society members belong to their local grassland society or discussion group. The Society provides a forum for discussion and the exchange of knowledge on a wide range of grassland related topics through workshops, on farm events and research conferences as well as technical and scientific publications. There is a strong tradition within the society to put science into practice and to ensure key messages are based upon evidence and tested under practical conditions not only under trials site conditions.
The Nutrient Wise Demonstration Programme has been a valuable tool in continuing the Societies objectives and BGS has been very grateful for the funding support of RDPE Programme administered through the SWARM Hub at the Rural Business School, Duchy College, for this work.

Lois Philipps
BGS Director
September 2013

Duchy College Rural Business School

The Rural Business School at Duchy College is a leading provider of education, training and knowledge transfer to the farming community, delivered through a broad portfolio of public and private funded activities including the RDPE-funded SWARM Hub project. The British Grassland Society, via the Nutrients Wise Demos project, is a key delivery partner within the SWARM Hub, and Duchy College is very pleased to support the publication of Soil smart and nutrient wise - a guide for on-farm practice. The publication contributes significantly to the overall project aim of providing farmers and growers with practical, up-to-date and unbiased information to help manage natural resources efficiently and make the right business decisions.

Dr Stephen Roderick
SWARM Hub Project Manager
Duchy College

The production of this book was funded via the Rural Development Programme for England as part of the British Grassland Society's Nutrient Wise Project, which forms part of the SWARM Hub managed by Duchy College. More information on the SWARM Hub project can be found at www.swarmhub.co.uk

Soil smart and nutrient wise
- a guide for on-farm practice

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The Basics

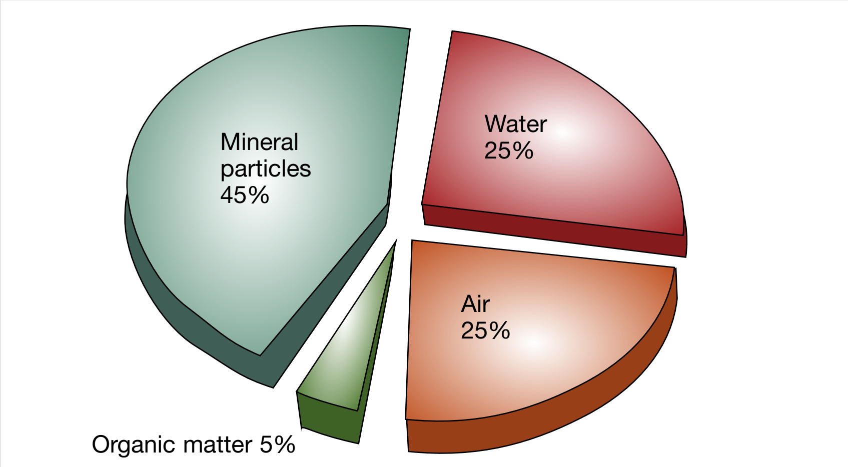
A guide for on-farm practice covering soil and nutrient management issues, aimed to help you:

- Manage your soil and nutrients to get the best from your grass and crops
- Take action to help with current challenges, by advising how to farm by season and not by the calendar

What is soil and what should it contain for good farming practice?

Soil is a porous material made up 40-46% mineral matter, 20-50% water, 10-25% air and 2-10% soil organic matter (SOM). The proportions vary depending on soil type. To understand the potential of your soils, manage soil structure and use nutrients in fertilisers and manures efficiently, it is very important to know the soil types (and soil textures) that you have on your farm.

The make-up of soil



The mineral particles can be made up of clay, silt and differing sizes of sand. The proportions of these three, along with the SOM, will dictate your soil texture and have a large influence on the nutrient content and nutrient holding capacity of your soil and also on how you manage soil structure – so understand if you have clay loam, sandy clay loam, silty loam, etc.

The difference between soil structure and soil texture and why it is important to know what your soils are to achieve best practice

Soil structure is the size and make-up of the soil particles and clumps. In order for soil to be porous and provide a good medium for plant roots to grow and get the nutrients that the plants need, the structure has to allow for an even distribution of the air, water, mineral particles and SOM through the depth of the soil.

Soil texture is determined by the amount of clay, silt and sand in the soil mineral particles. Texture will influence structure, e.g. very sandy soils can easily slumpand compact; clay dominated soils can become wet very quickly and also they dry out and crack very quickly; very silty soils can cap at the surface and suffer from wind erosion. The soil texture, along with SOM, governs what soil types you have. The basic soil types found on most livestock farms in the UK are shown below:

Sandy and light soil

Shallow chalk and limestone soil

Medium soil

Peaty soil

Heavy soil

Soil texture will determine how you manage soil structure to present the best growing medium for your grass and crops, but it is important to know your soil structure as well. Soil of any ‘texture’ can have ‘good’ and ‘poor’ structure and condition.

To assess your soil structure and condition, take a spade and pit 50cm x 50cm in the main body of the field – avoid edges, gateways, areas around trees and waterlogged patches. Inspect your soils in the growing season.

Digging a soil inspection pit

First – look at the soil surface. If this is solid and capped, then water will run off the surface and not through the soil. Surface run-off will lead to loss of nutrients and soil, and will restrict the water that roots need to grow and gain nutrients – always remember that roots can only take up nutrients that are suspended in water, so water flow is important to nutrient use efficiency and grass/crop growth.

Surface capping

Second – look at the topsoil down to 20cm. This is where the bulk of the plant roots do their work. Dig down in the pit to 20cm. Take slice of soil with the spade and remove it from the pit, holding it on the spade. Bang the spade on the ground and see how the soil breaks up.

The Basics

Good topsoil structure and condition

A good topsoil structure and condition will have:

- The soil breaking into small fragments and clumps
- A good ‘earthy’ smell
- Vertical cracks between the clumps
- About 10 to 15 worms in a 50cm x 50cm x 20cm section of soil
- A healthy brown colour throughout (no grey or orange patches)

Poor topsoil structure and condition

A poor topsoil structure and condition will have:

- The soil does not break up easily, or breaks into large clumps
- A bad ‘rank’ smell
- Horizontal cracks between the clumps
- Low numbers of worms, or none at all
- Mottled grey colouring indicating repeated waterlogging
- Compaction in the first 4 to 6cm caused by poaching during grazing, or a line of compaction lower down, caused by wheelings

Mottled grey colouring indicating repeated waterlogging

Surface compaction caused by poaching

To assess how porous your topsoil is, hold a 3cm cube of moist soil between your thumb and forefinger and apply gentle pressure. A well-structured soil will crack easily under this pressure and is termed ‘friable’. A poor structure is indicated when the cube only cracks under firm pressure or the maximum pressure exerted a thumb and forefinger; this shows a non-porous soil with high packing density that will restrict water movement and will have limited air content. This test is useful to confirm soil compaction from wheelings lower down in the topsoil that you might see at first sight, but are not sure about.

The importance of soil organic matter (SOM)

The SOM is made up of approximately 10% living organisms like bacteria, fungi and protozoa, 10% plant roots and 80% humus, which is dead and decade plant, animal and microbial matter.

The SOM will influence:

- Source of nutrients over time
- Nutrient retention
- Soil porosity (the flow of water within and through the soil)
- Water retention
- Soil structural stability

Organic manures like slurry and farmyard manure (FYM) and crop residues left after harvest and grazing will add to the SOM, whilst continuous cropping without replenishment will, over a long time, deplete SOM. Most grassland based soils are relatively high in SOM.

The benefits of improving SOM are:

- Provides major nutrients like nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) and micronutrients like copper (Cu), cobalt (Co), selenium (Se) and Zinc (Zn) – all of which are important for animal production.
- Maintain and improve soil structure
- Improve soil workability, reducing power and machinery costs
- Improve water holding capacity increasing growth during dry periods
- Improve crop establishment due to better water and nutrient availability
- Reduce waterlogging and increase the workability and grazing windows
- Improve soil pH buffering, potentially reducing liming requirements

The Basics

Field capacity and the importance of water

Water is very important to soil function and the transfer of nutrients from soils to plants. Plant roots can only take up N, P, K and S and all other nutrients if they are in solution in the soil, so having a good soil structure and well distributed SOM will help the soil to hold water and lead to plants taking up nutrients efficiently.

A soil that can hold no more water is said to be at 'field capacity'. This happens as plant growth slows and conditions wet-up during the autumn and as winter approaches; although soil capacity can be reached at any time if conditions are particularly wet. As the spring arrives and plants start to grow and use water, then soils will come out of field capacity. At this point the soil will take traffic from animals and machinery, without compaction from compression.

So, there is a critical balance to be judged between when soils are at field capacity and when they can take hooves and wheels. Increasing SOM and improving soil structure and condition will improve the window for grazing and field operations, but flexibility is key to allow soils to rest when they are too wet and not to damage structure by allowing grazing and wheeling when conditions are too wet.

The main nutrients to consider for grass farmers and why (including response to nutrients)

The major nutrients for grass and crop growth on livestock farms in the UK are:

NITROGEN (N) – for photosynthesis and growth. N is at the base of all proteins and enables plants to make and use sugars.

PHOSPHORUS (P) – for root development and energy. P is critical to the synthesis and use of energy by plants, allowing growth and development. P is particularly important for root development; a lack of P results in poor root and therefore plant growth.

POTASSIUM (K) – for turgour and nutrient uptake by roots. K helps plants maintain water balance so that they can stand up and turn towards the energy of the sun. K is also critical to the uptake of nitrogen and other nutrients by the root system.

SULPHUR (S) – for protein and sugar production. S is part of three of the main building blocks of proteins and some are vital to the ability of plants to make sugars. A lack of S leads to reduced sugar content, and therefore, reduced energy and growth.

CALCIUM (Ca) – for soil pH and plant structure. Ca is a main player in soil pH, which in turn is vital for nutrient uptake by plants. Ca is also involved maintaining a good 'friable' soil structure.

MAGNESIUM (Mg) – for nutrient balance. Too much Mg in soils and then plants can lead to 'grass staggers' (hypomagnesaemia) in livestock and tends to make soils 'sticky' and unfriable, but too little can result in an imbalance of K, Ca, Mg and sodium (Na), which can harm soil structure and the uptake of other nutrients.

SODIUM (Na) – for palatability. Na is not important for grass growth, but too little can reduce the palatability of grazed grass.

Trace minerals

There are a number of nutrients that are not needed in such high quantities as the major nutrients and are not important for plant growth, but are very important for animal health. These are the 'trace minerals' or 'trace elements'. Cu, Co, Se and Zn have been mentioned in relation to SOM, but iodine (I) and molybdenum (Mo) are also important.

These minerals are important in enzymes and hormones in the animal, which are vital for health, the production of milk and meat, and for fertility.

Interaction of soil texture and nutrients

Different nutrients are 'bound', loosely and strongly, to different parts of the soil mineral particles and organic matter. This means that certain soil textures and types may innately have more nutrients than others. So, it's worth knowing that:

- Soils with higher clay content tend to have more K, Mg, Ca and Na
- Sandy soils with a reasonable organic matter (3 to 5% SOM) tend to have lower K and higher P concentrations
- Higher SOM is associated with higher N content
- Silty soils tend to have higher P and lower K contents, and hold a lot of N if they have around 5% SOM
- Peaty soils have a high SOM content and therefore contain a lot of N, but will usually have a low pH (i.e. tend to be more acidic)
- Silty clay loam, sandy clay loam and all medium loam soils, with at least 5% SOM, will usually have an innate good balance of all major and trace minerals – particularly if they regularly receive organic manure applications

The Basics

Soil pH and nutrient availability

We have noted that plants only take up nutrients from the soil solution. The acidity or alkalinity of the soil has a large impact on this. If the soil is too acid (low pH), then nutrients get chemically locked up with aluminium and iron and are unavailable to plant uptake. Similarly, if pH is too high (alkaline soils), nutrients get bound to Ca and are precipitated out of solution and are not so available for plant to use.

The right soil pH for nutrient uptake on livestock farms is pH 6.5. Soil Ca plays a large role in governing soil pH, hence Ca limes can be used to raise the soil pH. The impact of soil pH on nutrient availability can be seen in the graph below.

pH effects the availability of applied nutrients

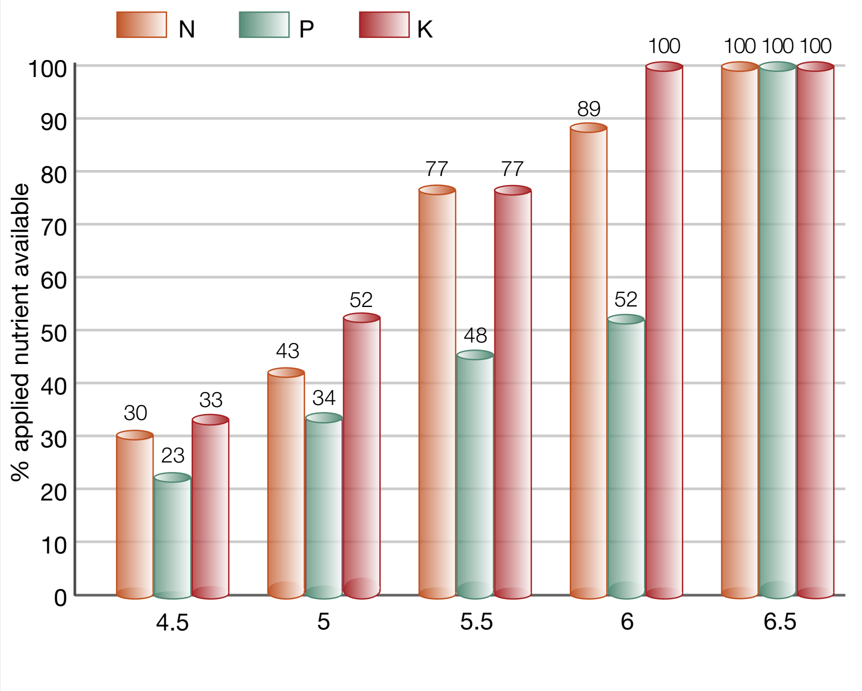


Figure adapted from www.aglime.org.uk

So if your soil pH is 5.5 and you apply a N fertiliser, only 77% of that fertiliser, at best, will be used by your grass and crops for plant growth; you are effectively throwing away 23% of the N which will probably be lost to the environment either to watercourses or the atmosphere. To put it another way, a £300 per tonne N fertiliser applied to grassland with a soil pH of 5.5, costs £390 per tonne to get the same impact in grass growth if your soil pH was 6.5.

Similarly, the availability of the useful P and K that is contained in organic manures will be reduced by 52% and 23%, respectively, if you run your soils at pH 5.5.

The basics of nutrient management planning (inorganic need = crop requirement – available soil reserves – organic manure contribution)

It's essential for your business and for the environment to only apply the nutrients that your grass and crops need to suit your system of milk and/or meat production. It should be noted that:

- Over application of N and P increases the risk of nutrient loss to the environment and is a waste of money and resources
- Under application of nutrients will lead to a short fall in home grown energy and protein for your system, which means you will lose money from loss of production or having to buy in more expensive supplementary feeds to fill the energy and protein gap.

The Basics

To work out what nutrients to apply and when, you will need to refer to standard figures of grass/crop nutrient requirement, soil reserves and manure nutrient content. You can do this yourself by using the RB209 Fertilisers Manual, or you can get a qualified and FACTS registered advisor to do it for you.

Whatever you decide, make sure that the following principles are followed for each field on your farm:

Inorganic (bagged) fertiliser needed = total grass/crop requirement – soil supply – contribution from organic manures

We can break this down into four logical steps:

STEP 1 Work out the grass/crop nutrient requirement

- Make sure you account for N, P, K and S
- Use the Fertiliser Manual (RB209) to look up the total nutrient requirement for grazed grass and conserved grass/forage crops

STEP 2 Work out what your soil will supply

- For N this depends on the management history in each field
- For P and K aim to maintain soil status at index 2 for both – this will minimise the need to apply P and K and protect the environment from P losses
- For S, make sure that you know if your soils tend to be S-deficient or not

STEP 3 Work out what you will apply with organic manures

- Look up the values of N, P, K and S available for grass and crop growth in the manures that you apply
- Remember that nutrient availability from manures will be affected by soil type, timing of applications and the technique used to apply the manure

STEP 4 Calculate what extra nutrients you need

- For each field and crop, work out what bagged fertiliser you might need by subtracting steps 2 and 3 from step 1, for each nutrient
- When the fertiliser products you need to meet the nutrient requirements and when you are going to apply these

Of course, all of this only works efficiently if your soils are in good condition and at the correct pH. If they are not, then you will lose nutrients and production potential; so get the soil structure right first.

Sampling and analysing soils and manures

It is very important to know the nutrient content of your soils if you are going to manage nutrients effectively and efficiently. Having nutrient analyses for your own manures will also give you more accurate nutrient management than just using book values.

Sampling soils:

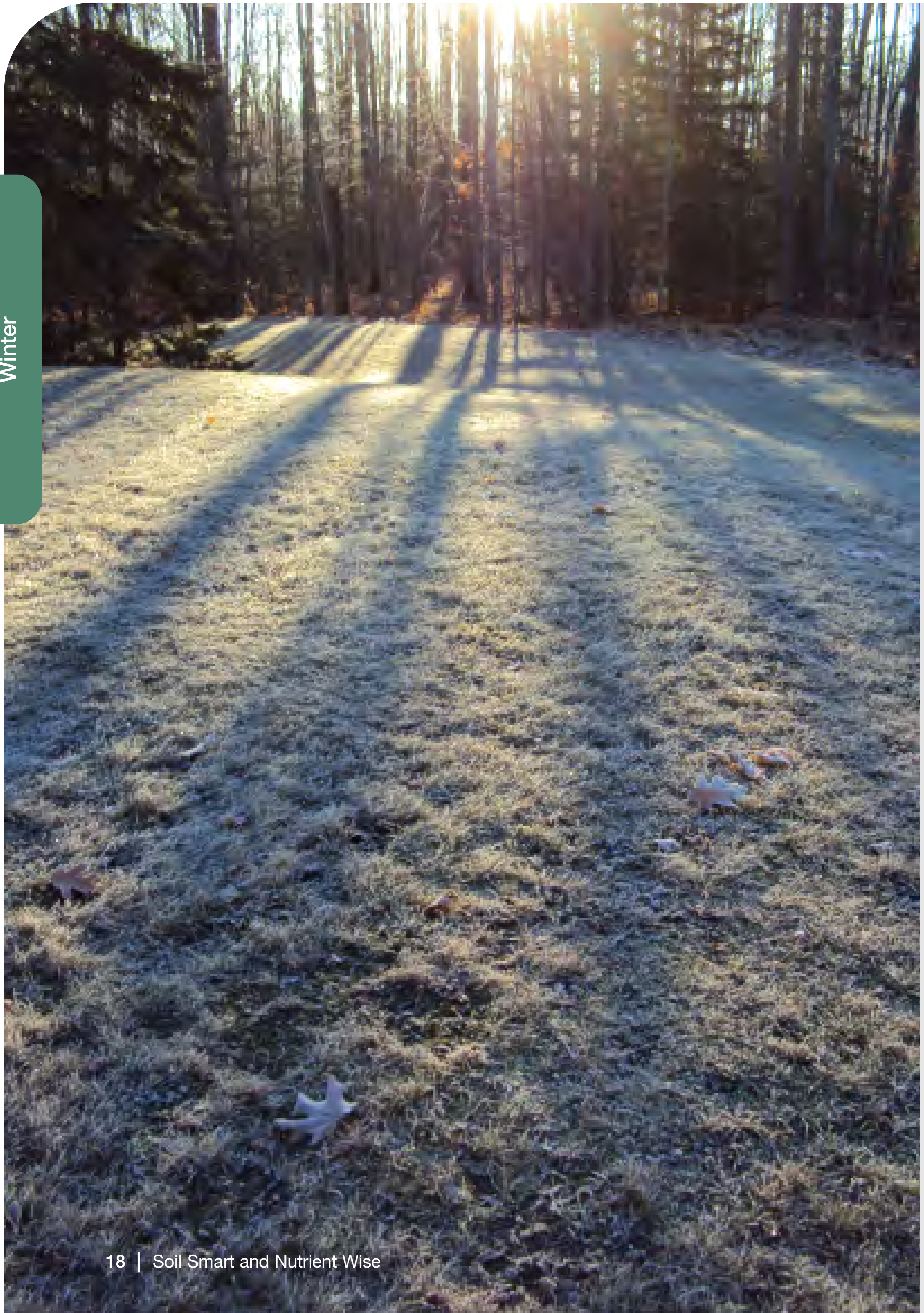
- For grassland use a ‘gouge’ or ‘pot’ corer
- Sample between autumn and spring
- Take about 25 samples per field, each at 7.5cm depth (3 inches)
- Avoid field edges, gateways, trees and unusual areas (e.g. waterlogged patches)
- Take samples randomly, walking the field in a ‘W’ fashion
- Mix the soil thoroughly and send to the laboratory as soon as possible after sampling
- Sample every field every 3 to 4 years
- If a field has different soil types, or has been managed differently in certain parts, then take separate samples in each distinct part.

Sampling slurries:

- Be very careful sampling slurries – never sample from a silo – always sample from a tanker during application
- Take a representative sample of the material applied and send it to a laboratory for dry matter (DM), N, P, K, Mg and S content as soon as possible
- Taking a number of samples over time will enable you to build up a picture of the nutrient content of your slurries and how these differ from book values
- There are on-farm test kits for estimating the N content of your slurry and these work well, but will not give you a P, K, Mg or S content
- Take about 5 litres of slurry in total from a few tankers. Mix this thoroughly and take a 500 ml (half a litre) sub-sample to send off to the lab.

Sampling farmyard manure (FYM):

- Make sure that the manure heap is dry and safe enough to walk on
- Sample from 10 areas that are representative of the FYM heap, just before the material is to be applied
- Clear away any weathered material with a spade or fork, dig a 0.5 m hole and take a 1 kg sample from this for each location
- Mix the samples thoroughly and take a 0.5 kg sub-sample to send to the lab.



Winter

The Winter

Frost and dormant soils - a chance to recover

As temperatures drop below 5 °C, microbial activity slows and soils get a chance to recover before the next season. The main issue with grassland soils is compaction and the first point to understand in improving soil management is that natural processes affect soil structure, as well as farming operations, and these need to be considered in managing soils for good condition.

Soil structure changes naturally due to weather related factors such as wetting and drying and freezing and thawing. So the recovery of a compacted soil is greatly influenced by the swelling and shrinkage of soils (particularly if they have a significant content of clay) and by frost action. For example, in areas where soil freezing in winter is slight or absent, the compacting effects of wheeling and poaching are liable to last longer than where hard winter frosts are regular.

Soil compaction – causes and remedies

Compaction type	Typical cause	Possible remedies
Surface capping (0-10cm deep)	Grazing in wet conditions. High stocking densities. Rainfall on new cultivations.	Lime/introduce organic matter to encourage earthworm activity to break cap. Soil aerator or pasture slitter with spikes or knives in spring. Plough if reseed needed.
Machinery (10-15cm deep)	Silage and muckspreading operations. NB the first wheeling creates 70% of the damage so use the same tramlines if possible.	Soil aerator with spikes or knives in spring. Subsoiler or sward lifter. Plough.
Plough and deep pans (15cm+ deep)	Repeated re-seeding at one depth.	Subsoiler or sward lifter in autumn. Mole-plough (heavy soils only). Deeper plough just below pan.

If you are worried about the condition and structure of a soil, dig some soil pits and take a look before field capacity is reached and the soil gets too wet.

Winter

Drainage – checking and improving

Putting in drainage is expensive (around £1,000 per acre / £2,500 per ha), so checking and clearing drains and maintaining them is important. Soils with poor or failed drainage are more waterlogged and will not support productive species and good yields.

- Check drains in wet patches
- Clear blocked drains
- Mole-plough on heavier soils when conditions allow to assist drainage

Leatherjackets and moles

Leatherjackets are the grubs of the crane fly, or 'daddy long-legs'. They live just below the soil surface. From August through to the following June, they eat the roots of grasses and other plants. Numbers vary from season to season, but counts of leatherjackets from November to April give an indication of the damage that will be caused and whether chemical control will be worthwhile. The most up to date information can be gained at **www.sruc.ac.uk** (the website of the Scottish Rural University College).

Applying chemical (usually chlorpyrifos) treatments before the land is ploughed is always better than waiting until the damage is underway, but in targeting a pesticide programme, account should be taken of soil conditions – the land must be dry enough to travel on and soil temperature has to be above 5 °C. Successful treatment will reduce the leatherjacket population by 50%.

Mole damage to grassland is very visual and can often look worse than it is. Moles will leave an area in time, but if more than 10% of a field damaged, then employing a mole catcher will be economically worthwhile. In silage fields, mole hills can lead to soil getting into silage, with consequent spoilage and waste, so pay particular attention to cutting fields.

Sampling soils and manure

It's a good time to think about soil sampling before conditions get too wet. Remember that analysis should show the following for optimum nutrient use efficiency:

- pH 6.0 – 6.5
- P, K, Mg, Index 2

If you need to build soil P and K status to this level, or run it down to optimum, you will only know if you sample your soils and get them analysed.

To get an estimate of the amount of P and K required to build soil to index 2 can be obtained from **http://www.pda.org.uk/app/pkcalculator.html** - this will take account of your current soil status and soil type.

Adjusting soil pH

Late autumn and early spring / just coming out of winter are good times to use liming materials to adjust soil pH to optimum. It will take 6 to 12 months for a liming to effect soil pH.

- From the pH of your soil analysis, assess how much liming material you might need to get to the correct pH:

Recommended lime application rates for ground limestone on grassland soils (t/ha) multiply by 0.41 to get t/acre

Measured soil pH	Sands and loamy sands	Sandy loams and silt loams	Clay loams and clays	Organic soils (10-25% organic matter)	Peaty soils (over 25% organic matter)
6.5	0	0	0	-	-
6.4	2	2	2	-	-
6.3	2	2	2	-	-
6.2	2	2	2	0	-
6.1	2	2	2	2	-
6.0	2	3	3	2	-
5.9	3	3	4	2	-
5.8	3	4	4	3	0
5.7	4	4	5	4	2
5.6	4	5	5	5	2
5.5	5	5	6	5	4
5.4	5	6	7	6	5
5.3	5	6	7	7	6
5.2	6	7	7	7	7
5.1	6	7	7	7	7
5.0 & below	7	7	7	7	7

Adapted from aglime.org.uk

- Do not apply more than 5 t/ha of a liming agent in one application
- If soil Mg status is above 2, do not use liming materials that contain Mg
- Different liming materials vary in their neutralising value (NV) which is a measure of their ability to raise soil pH. The higher the NV, the less you need to get an effect (see table below):

Recommended application for different liming materials to two typical grassland soil types to raise soil pH from 5.8 to 6.5

Liming material	Typical Neutralising Value (NV)	Sands and loamy sands ('light' soils)	Sandy loams/silt loams ('medium' soils) and clay loams/clays ('heavy' soils)
Ground limestone	54	3	4
Screened limestone/dust	50	3.75	5
Coarse screened limestone /dust	55	4.5	6
Ground magnesian limestone /dust	55	2.85	3.8
Screened magnesian limestone /dust	55	3.6	4.8
Coarse screened magnesian limestone	55	4.2	5.6
Ground Chalk	50	3.3	4.4
Screened chalk (1 inch to dust)	45	4.5	6
Lump chalk	45	8.4	11.2
Ground burnt lime	85	2.65	2.2
Kibbled burnt lime	85	1.8	2.4
Magnesian burnt lime	90	1.5	2
Kibbled magnesian burnt lime	90	1.65	2.2
Hydrated lime	65	2.25	3
Silicate liming materials (slags)	40	3.6	4.8
Calcareous sea sand	40	3.5	6
Sugar beet factory co-product	26	6.2	8.3

Adapted from aglime.org.uk

A lot of useful information on liming can be found at **www.aglime.org.uk**

NMPs and crop rotations

Doing a Nutrient Management Plan (NMP) for your whole farm every year is the best way to plan the use of nutrients and operate your system for optimising efficiency and grass/crop growth. The winter is an ideal time to step back and plan ahead.

Your NMP should:

- Plan grass and crop growth on a field-by-field basis
- Account for nutrients available from the soil and organic manures
- Plan manure and bagged fertiliser applications to meet grass and crop requirements
- Allow you to record what actually happens against the plan and make adjustments to react to the season as it progresses
- Show how you are building soil fertility, or reducing it, to optimum levels
- Take advantage of any crop rotations you might have, for example, to use the N left behind from a grass/clover to support the yield of an arable crop

When you are thinking through crop rotations:

- See if they can be used to manage soil structure and condition – e.g. by growing an arable crop after grass/clover to use the N left behind and use the plough to get rid of soil compaction
- Try and rotate crops that take a lot of slurries and manures (e.g. maize) around the farm. This will ensure that soil P and K status is not driven too high and that the whole farm gets the benefit of manure applications and ploughing

Assessing pastures and the need to reseed and/or patch

Winter is also a good time to look back at how your grass swards have performed over the season and deciding on what needs to be reseeded, as well as considering how you might achieve the best results.

When to renew a grass ley:

- If you measure grass yields, consider reseeding when annual yields decline to 80% of what you are aiming for
- If the sward contains less than 40% of the original grasses that were sown
- If there is a bad weed problem (broad-leaved weeds like docks making up more than 15% of the sward content)
- If soil structure has become so compacted that ploughing is necessary to put it right

Perennial ryegrass has a purple base – how much is in your swards?

Benefits of renewing grassland that is under performing:

- Increased grass yields
- Introduce new grass and clover varieties
- Improve palatability and quality
- Reduce N requirements if clover is included in the mix
- Opportunity to tackle weeds
- Opportunity to remove soil compaction.

Plough or direct drill?

Winter is a good time to assess sward condition and decide whether or not reseeding should be planned for next season. The decision comes down to weighing up the cost/benefit in each situation, as well as the state of the soil condition.

A compacted soil is likely to go with an underperforming sward, but dig inspection pits to assess where the compaction is and its extent before deciding what to do. A soil with compaction right down the profile will often need to be ploughed to alleviate the compaction issues, whilst sward lifting/spiking followed by direct drilling might be better where compaction is more minor. However, you won't know the situation unless you dig to look at what's going on.

Reasons to reseed

- Increase yield
- Boost quality
- Clean grazing
- Rotation
- Weed control
- Improve soil structure
- Change of system

Do you know how well is your grass performing?

If you don't measure it, then it's more difficult to manage it. Some of the following methods will enable you to assess grass performance:

- Plate meter
- Grazing days
- Trailers / bales produced
- Milk tank
- Analysis

Winter

The cost of grass

Grass is the cheapest feed you have, but it may not be as inexpensive as you think. A poorly performing sward may provide DM that is twice the cost compared to a new reseed or good grass ley:

	Good ley	Poor ley
Yield (t DM/ha)	12 t	8 t
Quality (MJ ME/kg DM)	12 ME	10.5 ME
Response to N (kg:kg)	25:1	15:1
Cost (p/kg/DM) - grazed	3 – 5p	8 – 12p
Cost (p/kg/DM) - silage	8 – 10p	16 – 20p

Production loss as grass swards decline

As grass leys age, they tend to decline in performance. Where are you on the scale?

Age of ley	Yield (t DM/ha)	ME (quality) (MJ/kg DM)	Lost energy (ME '000s / ha)	Milk equivalent (litres/ha)	Concentrate replacement cost for ME (£)*
1	13.0	12.0			
2	12's	11.8	6	1,130	135
3	11's	11.6	18	3,400	400
4	10's	11.4	30	5,860	670
5	9's	11.2	42	7,920	935
6	8's	11.0	54	10,190	1,205
7	7's	10.8	72	13,580	1,610

*Assumes concentrate costs £240/tonne and contains 12.5 MJ ME/kg DM

Note that the speed of decline depends on:

- Grazing / cutting management
- Soil chemistry
- Soil structure
- Weather
- Variety choice
- Weed control

If your management has been very good, then you might have an older sward which is still performing well and doesn't require a reseed. Remember, you won't know where you are unless you measure what you get from a sward and track progress.

Typical reseeding costs (£/ha):

Action	Plough	Direct drill
Round-up (full rate)	25	25
Spray	15	15
Plough	57	-
Drill	-	92
Harrow (2 passes)	44	-
Roll	12	12
Combination drill	45	-
Roll	12	-
Fertiliser cost	222	222
Fertiliser application cost	14	14
Seed cost	140	140
TOTAL	**£586/ha**	**£520/ha**

Winter

Warming up / Early Spring

Soil temperatures

Grass starts to grow when the soil temperature at 10cm depth is consistently at 5 to 6 °C. This point is obviously dependent on season conditions and your own circumstances and you may have had some grass growth over the winter.

Apply fertiliser when the soil temperature is right

Applied nutrients will only be taken up by plant roots and used for growth when soil temperature is at this level, so it is worth knowing when your soils are warming up. Apply nutrients too early and some will be lost from the soil/plant system; apply them too late and you will have missed a growing opportunity. So, investing £20 or so in a soil thermometer can pay great dividends.

Dry enough to work?

Your soils might be warm enough to use nutrients for grass and crop growth, but are they dry enough to work on? This will depend on your soil type and soil condition. Heavy compacted soils will dry out more slowly than lighter soils and those with a good structure that allows efficient drainage.

If you work soils or travel on them too early, then you will cause damage by compaction. Assess if your soils are dry enough to work by walking the fields and digging some inspection holes; don't just look over the fence and take a guess.

Warming up / Early Spring

Worms

Earthworms burrow through soil and feed on organic matter, improving the movement of air, water and nutrients through the soil, so they are important for soil health, nutrient use efficiency and grassland production. Remember, you should have the same live weight of worms in the soil of a field as you have stock on it – that means around 15 worms in a 50cm^2 soil pit, when you are doing your soil inspection in spring/summer. **Note though that you may not see many worms when inspecting soils in winter or dry conditions.**

And you want a combination of types. Not all earthworms are the same, with different species having different burrowing and feeding habits. There are three main groups that live at the soil surface (Epigeic), in the uppermost topsoil (Endogeic) and deeper down (Anecic).

Spiking (aerating) and rolling

The urge to burn some diesel in spring can be strong! But do you need to?Rolling grass fields can be useful in flattening the topsoil to make sure that soil isn't harvested along with cut grass, causing spoilage in silage making. But rolling when it is too wet will cause compaction and flattened grass will take a check in growth. So rolling grazing fields is definitely a waste of time and energy.

If you find surface compaction (down to 5cm or 6cm) when you dig your inspection pits, then it is worthwhile considering soil aeration with a spiking machine. This can let air into the soil, improving drainage and soil health. Make sure that you aerate in appropriate conditions – too wet and the blades will simply smear the soil and not open it up; too dry and the blades will not penetrate the soil sufficiently. Also, make sure that the machine is weighted appropriately so that the blades penetrate the soil, and don't travel at more than 3mph when spiking.

And be patient with aeration – if surface compaction is an issue, it may take several season of spring aeration to show improvements.

Grassland aerator (spiker)

Warming up / Early Spring

Weeds

Early spring is a good time to assess the weed burden on your grassland and take action for control if you need. Weeds can be controlled by making sure they are grazed and/or cut before they flower and for docks by not applying slurry repeatedly to the same fields – although these techniques take longer to effect control than using chemical sprays. If you do decide to use chemical sprays and seek advice, always make sure the adviser is BASIS qualified.

Docks

- If docks cover 10% or more of the sward, you will get an economic response from treatment – this can be assessed visually in the sward; a 10% cover of docks looks like one dock plant approximately every 3 to 5 metres as you walk across the field
- Chemical treatments usually involve combinations of clopyralid, fluroxypyr and triclopyr
- Treat when the dock rosette is actively growing and is 15 to 25cm in diameter
- Always follow the manufacturer's instructions
- Products are usually not 'clover safe' so make sure you don't knock out clover from the sward with the treatment
- Spot and wipe-on treatments are available for clover-rich and grazing swards.

Weeds in organic grassland

The best option for organic growers (like non-organic) is to keep grazing tight and cut at the right times to reduce the chances of weeds establishing and taking control. However, where there is a problem, repeated cutting before flowering, season after season, will weaken the weeds and reduce their competitive ability, so that over time control will be achieved.

Nettles

- Treatments usually involve combinations of clopyralid, fluroxypyr and triclopyr
- Treat when the nettles are actively growing just prior to flowering
- Always follow the manufacturer's instructions
- Products are usually not 'clover safe' so make sure you don't knock out clover from the sward with the treatment
- Spot and wipe-on treatments are available for clover-rich and grazing swards.

Thistles

- The two most damaging thistles are creeping or spear (scotch) thistles
- Treatments usually involve combinations of fluroxypyr and aminopyralid, or clopyralid, fluroxypyr and triclopyr
- Treat when the thistles are actively growing and have 4 to 10 leaves
- Always follow the manufacturer's instructions
- Products are usually not 'clover safe' so make sure you don't knock out clover from the sward with the treatment
- Spot and wipe-on treatments are available for clover-rich and grazing swards

Fertiliser and manure applications

At this stage of the season, you should have your NMP together, so that you know what organic manure and inorganic fertiliser applications you intend to make to each field and crop.

Don't forget:

1. Inorganic fertilisers should be applied when soil temperature and conditions allow. You have a window of about 2 weeks either side of when soil temperature hits 6 °C, where your first N application of the season will be used with 90 to 100% efficiency.
2. Make sure that your fertiliser spreader is maintained properly and is calibrated for each fertiliser product that you use. The fertiliser manufacturer may be able to give you indicative setting for your machine, but make sure that you calibrate to your own conditions.
3. The amount of N that is available from organic manures for the grass or crop that you are growing this year depends on:

   a The type and quantity of manure applied
   b Soil type
   c Timing of application
   d Method of application

The following table on the next page, gives an indication of what you will get in terms of N from manures and how considering changing applications method and timing might bring additional available N.

Tray testing to calibrate a fertiliser spreader

The amount of available N in 10m3/ha slurry applications depending on soil type, timing of application and application method.

Timing	Autumn (Aug – Oct), 450 mm rainfall to end of March		Winter (Nov – Jan), 250 mm rainfall to end of March		Spring (Feb – Apr)	Summer use on grassland
Soil type	**Sandy/shallow**	**Medium/heavy**	**Sandy/shallow**	**Medium/heavy**	**All soils**	**All soils**
	Organic manure					
Cattle slurry – splash plate applied						
2% DM	0.8 [1.6]	4.8 [5.6]	4.8	4.8	7.2	5.6
6% DM	1.3 [2.6]	6.5 [7.8]	6.5	6.5	9.1	6.5
10% DM	1.8 [3.6]	7.2 [9.0]	7.2	7.2	9.0	7.2
Cattle slurry – ploughed in 6 hours after application						
2% DM	0.8 [1.6]	5.6 [6.4]	4.0	5.6	8.0	N/A
6% DM	1.3 [2.6]	7.8 [9.1]	5.2	7.8	10.4	N/A
10% DM	1.8 [3.6]	9.0 [10.8]	5.4	9.0	10.8	N/A
Cattle slurry – band spread						
2% DM	0.8 [1.6]	4.8 [5.6]	4.8	4.8	8.0	6.4
6% DM	1.3 [2.6]	6.5 [7.8]	6.5	6.5	10.4	7.8
10% DM	1.8 [3.6]	7.2 [9.0]	7.2	7.2	10.8	9.0
Cattle slurry – shallow injected						
2% DM	0.8 [1.6]	4.8 [5.6]	5.6	5.6	8.8	7.2
6% DM	1.3 [2.6]	6.5 [7.8]	7.8	7.8	11.7	9.1
10% DM	1.8 [3.6]	7.2 [9.0]	9.0	9.0	12.6	10.8
Dirty water – surface applied	0.5 [0.75]	1.75 [2.0]	1.75	1.75	2.5	1.5
Separated cattle slurry (liquid portion) – surface applied						
Strainer box – 1.5% DM	0.75 [1.5]	4.5 [5.25]	4.5	4.5	6.75	5.25
Weeping wall – 3% DM	1.5 [3.0]	9.0 [10.5]	9.0	9.0	13.5	10.5
Mechanical separator – 4% DM	2.0 [4.0]	10 [12]	10	10	14	10

Adapted from RB 209 (DEFRA Fertiliser Manual). N/A = not applicable
Figures refer to N available to the next crop for all grass and crop species, except figures in brackets [x], which refer to N available to next grass and winter oilseed rape crops only. Typical slurry DM contents are 6% for cattle slurry and 4% for pig slurry, but yours may differ so it is always worth getting your own organic manures analysed.

Splash plate application – don't let the splash reach 4m above ground level

Dribble bar slurry applicator

Trailing shoe slurry applicator

Injecting slurry

The amount of P and K that you get from these applications is not dependent on timing or method of application. The values are given below:

Total and available amounts of P and K in different organic manures applied at a rate of 10m3 or 10t/ha (fresh weight basis).

Organic manure	Total phosphate kg $P_2O_5/10m^3$ or t	Available phosphate kg $P_2O_5/10m^3$ or t	Total potash kg $K_2O/10m^3$ or t	Available potash kg $K_2O/10m^3$ or t
Cattle FYM	32	19	80	72
Pig FYM	60	36	80	72
Sheep FYM	32	19	80	72
Poultry layer manure	140	84	95	86
Poultry broiler litter	250	150	180	162
Cattle slurry 2% DM	6	3	24	22
Cattle slurry 6% DM	12	6	32	29
Cattle slurry 10% DM	18	9	40	36
Separated cattle slurry (liquid portion)				
Strainer box	3	1.5	22	20
Weeping wall	5	2.5	3	2.7
Mechanical separator	12	6	35	32
Separated cattle slurry solid portion (20% DM)	20	10	40	36
Dirty water	1	0.5	10	10
Pig slurry 6% DM	18	9	24	22

Adapted from RB209 (DEFRA Fertiliser Manual).

Ploughing and other cultivations

Whatever ploughing, direct drilling or minimum tillage operations you carry out, make sure you dig soil inspection pits before and after the work. This will help you to:

- Make sure that you are dealing with the compaction issues as they exist and are using the right technique for the job in that particular field
- Have confidence that the job done is fit for purpose and will achieve success

If you are going to plough, make sure you have weighed up the pros and cons…

The pros:

- Removal of general compaction and plough pans through the whole soil plough-depth profile, and across the whole field
- Complete aeration of the soil, allowing a ‘fresh start’ for the soil microbes and animals (earthworms), which will lead to release of nutrients from the soil through mineralisation
- The opportunity to remedy other issues at the same time, such as soil pH
- The opportunity to make effective use of slurries and manures incorporated into the soil for optimum use of the nitrogen that they contain
- A boost in grass yields (if reseeded with grass) that will last for 3 to 5 years
- Weed control

The cons:

- Greater cost than less invasive treatments for soil compaction (at least £35/ha for ploughing with up to £100/ha including all secondary cultivations and drilling)
- The possible need to control weeds during grass/crop establishment
- Large release of nitrogen through soil mineralisation can lead to pollution of water if the N is leached
- Formation of compacted plough-pans if ploughing is routine, for example in continuous maize or short-term grass leys

Spring Surge / Post Magic Day

Planning for good grass growing year - and being flexible to react to the season

Making the most of any season means planning and attention to detail throughout the year, but getting the most out of spring growth will have the largest impact on making milk and meat from grass – 30 to 50% of annual grass growth will come in spring.

So the key is to plan for a good grass growing season and then be attentive and flexible to react if growth is above or below expected.

So for rotational grazing, plan to hit:

- Entry into paddocks at 2,700 to 2,900 kg DM/ha
- Leave residuals as close as possible to 1,500 kg DM/ha (3.5cm)
- Average farm cover of 2,100 kg DM/ha

Grazing down from 2,800 to 1,500 kg DM/ha

If you go by sward height, maintain continuously grazed swards in spring at:

- 6cm to 8cm for dairy cows and beef cattle
- 4cm to 6cm for sheep with lambs

To utilise as much grass as possible and maintain growth and quality for the rest of the season, make sure that you maintain target grazing heights and residuals – if growth is better than expected, take out areas for silage/conservation so that target heights can be maintained.

If growth is less than expected, expand the grazing area.

Remember:

- If nutrients in the soil are unbalanced, then the grass will take up more of one particular type than is good for grazing stock – for example, if sodium and/or magnesium levels are low, then the plants will tend to take up more potassium than the animal require, which can contribute to grass staggers (hypomagnesaemia)
- To avoid grass staggers always make gentle changes to nutrition by reducing the winter ration gradually and introducing grazing gradually over a number of days. Make sure that magnesium licks are also available or that magnesium is included in the concentrate elements of the diet.
- Be aware that introducing stock to clover-rich pasture too quickly can lead to bloat; particularly in paddock grazing – make the transition carefully over a few days and use bloat control measures as appropriate.

Spring poaching

Dig inspection pits to assess the degree of compaction and damage caused by poaching. If only the top few centimetres are effected, then the sward will probably come back to you – you could consider spike aeration if conditions allow to get air into the topsoil.

If the compaction has caused damage down to 6cm, then you may need to consider reseeding later in the season, but first let the sward recover and assess the regrowth for yield and quality before making a decision.

Measure grass growth to understand the impacts of your winter managements and decisions

The main outcome of good practice in managing soils and nutrients is efficient milk and meat production from your grass based system. However, this can be a longer term assessment – you need measurements that tell you how you are doing now.

So, be proactive in routinely assessing grass growth and quality – you will get a handle on what is going on now and over time you will build up a picture of the impacts of your management of soil and nutrients on your production efficiency. There are plenty of simple ways of assessing grass growth and quality:

- Milk and meat quality and yield per ha
- Sward meter (rising plate) measurements giving tonnes DM/ha
- Grazing days in each field (note the number and type of animal grazing and for how long in each field)
- Silage trailers per ha or in each field, for each cut
- Silage quality
- Quality of grazed grass (take samples just before grazing starts and send to the laboratory for assessment of energy, protein and digestibility)

Spring reseeding

This should be a decision that you have already made over winter from an assessment of measurements of previous growth and quality, the state of the sward and the soil condition.

Refer to the reseeding section of ‘Winter’ for guidance.

Ammonium nitrate vs. urea

Nitrogen losses occur from both urea mainly by ammonia volatilisation, and from ammonium nitrate (AN) by nitrate leaching.

Losses of N (% applied lost to volatilisation of ammonia and leaching of nitrate) from urea and AN fertilisers applied to grass and arable crops over three seasons

Fertiliser applied to:	Urea		AN	
	Average loss (%)	Range (%)	Average loss (%)	Range (%)
Grassland	27	10 – 58	2	0 – 13
Arable cereals	22	2 - 43	3	0 - 10

To minimise losses of N from urea, apply to grassland in spring only and when the average air temperature and total rainfall in the three days following spreading is forecast to be up to 10 °C and at least 5 mm.

Relative response (%) of grass growth to applications of urea N compared to AN depending on rain and temperature conditions. Values above 100% indicate a grass growth advantage to urea N (highlighted in green); values below 100% indicate an advantage to AN(highlighted in red).

Amount of rain falling in the 3 days after N application	Average air temperature in the 3 days following N application				
	0 °C	5 °C	10 °C	15 °C	20 °C
0 mm	90	84	79	73	68
5 mm	100	95	90	84	78
10 mm	111	106	100	95	90
15 mm	123	117	111	106	100
20 mm	133	128	123	117	111

The practical outcome of this table means that:

- Urea can hugely outperform AN in terms of grass growth, but it can also massively underperform. This is shown in teh table as the range of grass growth response is from +33% to -32%.
- You have to know what the forecast is showing for rainfall and temperature to get it right
- There is more chance of having success with urea in the spring when rainfall is frequent (providing more than 5 mm in the three days after application) and temperatures are relatively low (averaging less than 10 °C in the three days after application)

Do not use urea outside of the spring period unless it contains a urease inhibitor.

Total ammonia loss and yield of grass with urea, urea+0.5% nBTPT inhibitor and AN

Fertiliser	Ammonia losses (% of N applied)	Spring grass yield (t DM/ha)
Urea	8.1	2.99
Urea + 0.5% nBTPT	1.9	3.26
AN	0.1	3.28

From Watson *et al.,* The Journal of Agricultural Science vol. 119 (1990)

- Minimise losses from AN by applying when damp conditions are forecast
- Minimise N losses from all fertilisers and manures by avoiding spreading if heavy rain (that might cause run-off) is expected and only apply to the nutrient requirements of the grass/crop (see ‘The Basics’ section)
- If conditions are right (low temperatures and wet) urea can outperform AN in grass growth by 20 – 30%, but if conditions are wrong (mild/warm and/or dry) then AN can outperform urea by the same amount.

Spring Surge / Post Magic Day

Summer

Summer poaching

Fields that are poached in summer can be treated the same as those that are poached in spring – if damage is really bad, then there is still time to do a late summer/autumn reseed.

Dig inspection pits to assess the degree of compaction and damage caused by poaching. If only the top few centimetres are effected, then the sward will probably come back to you – you could consider spike aeration if conditions allow to get air into the topsoil.

If the compaction has caused damage down to 6cm, then you may need to consider reseeding later in the season, but first let the sward recover and assess the regrowth for yield and quality before making a decision.

Too wet or too dry to apply fertiliser and manures?

Weather conditions in summer can be as variable as any other time of year. Many grassland farmers suffer a 'summer drought' where rainfall is low (less than 350mm between April and September) and grass growth slows as a result.

Always look at the long-range and short-term weather forecast if you think conditions are too wet or dry to apply nutrients. The challenge is making sure that there is enough moisture (but not too much) to use fertilisers and organic manures efficiently.

- If you can't travel on the soil without compression damage, then it's too wet to apply fertilisers and manures.
- If the soil is very dry and you won't get rain within 48hrs of applying nutrients, then it's too dry to make applications

If you apply at the wrong time, then you may lose N by:

RUN-OFF: If soils are saturated with water, or close to it, then additional rain can result in soil (and therefore) nutrients flowing off the soil surface. This isn't usually a problem in summer, but can occur if there is extreme 'flash-flood' type rainfall.

Run-off risk near a watercourse

To reduce the risk on nutrient loss from run-off, which loses nutrients (N, P, K and S) from the system and damages water quality in the environment, you need to work on the following:

SOURCE – This is the soil.

- Do not over apply N from fertilisers or manures at any stage (50m3 slurry per hectare in any one application (30m3 in February just after the NVZ closed period) is the regulatory limit and there are N-Max limits for the available N that can be applied to any grass or crop from bagged and manure fertiliser – see NVZ regulations)
- Maintain soil P and K indices at 2

PATHWAY – This is how soil and nutrients can 'run-off' the field.

- Carry out ploughing and other operations that leave bare soil as quickly as possible
- Plough along the contours of a field slope, not up and down
- Make sure that soil condition is good – so good organic matter and worm populations, good structure with no surface capping or sub-surface compaction. For example, harrowing or lightly cultivating maize fields after harvest will reduce surface capping to avoid run-off

RECEPTOR – This is any water course or water body that can be polluted by run-off. Protect water receptors by:

- Using buffer strips (usually uncut grass) at the bottom of sloping fields near watercourses
- Don't put access gates (permanent or temporary) or water troughs down at the bottom of slopes next to watercourses (the poaching will encourage run-off)
- The regulations require that you don't apply any nutrients, from any source, within 10m of a bore whole or standing water body like a lake or mere

LEACHING: Leaching occurs when water that cannot be held by the soil is lost to drainage. Drainage is normal during the winter months; the soil will be in 'moisture deficit' during the summer when many of the pores that can hold water are dry, so it is only very rarely a problem in summer.

DENITRIFICATION: This is the loss of nitrate N as a gas. It's a natural process that involves bacteria in the soil, but not one that we want.
To avoid this loss:

- Match N applications to crop requirements
- Avoid applying N in warm conditions after a heavy shower
- Leave a 4 to 5 day gap between applying slurry and inorganic N fertiliser to the same sward
- Avoid spreading slurries in wet conditions

VOLATILISATION: Volatilisation is the loss of ammonium N from the soil as ammonia gas. As well as being a loss of N from the system, ammonia in the atmosphere reacts to form acid rain. To avoid this loss:
Avoid applying ammonium N sources when the soil is wet and rapidly drying
Use band spreading, dribble bar and injection of slurries rather than a splash plate applicator

Summer

Summer

Reseeding in summer and autumn

This should be a decision that you have already made over winter from an assessment of measurements of previous growth and quality, the state of the sward and the soil condition, or you have decided to reseed to rectify damage caused by poaching earlier in the year.

Refer to the reseeding section of 'Winter' for guidance.

In addition for summer and autumn reseeding, make sure that you graze down (or cut and then graze down) the existing sward as much as possible before ploughing or direct drilling. This will:

- Make sure you get the last drop of production from the existing sward
- Reduce weed burden
- Make the application of a 'burn-off' spray more effective

If you are going to plough, then this grazing-off can be achieved by mob-stocking, as any compaction should be rectified by the plough. Mob-stocking is where youngstock or sheep are used to graze-off the sward quickly with many more animals than you would usually use.

Using clovers

Summer and autumn are the times when the later growing clovers come into their own. It's good to consider the use of clover if:

- You want to reduce your nitrogen fertiliser applications
- You apply less than 150 kg N/ha in bagged fertiliser (clovers can provide this level of input for you)
- You are prepared to manage the sward to maintain the clover content
- You want to gain palatability and sward quality (protein and digestibility) advantages from clovers
- Your system is not too dependent on very early spring growth

Using white and red clovers in mixtures with perennial ryegrass:

- Contributes 50 – 250kg N/ha from clover fixed N
- Improves the digestibility, protein and mineral content of herbage where the clover contributes significantly to the sward

As a rule of thumb, a grass/white clover sward will fix 50kg N/ha for every 10% ground cover of clover. You can assess this by eye:

Relationship of visual clover content to actual content of clover DM in mixed swards and the amount of N fixed to the system.

% ground cover of clover (visual)	% clover in sward dry matter	Kg N/ha fixed in the season
20	5	25
30	15	75
40	20	100
50	25	150
60	35	175

Grass/clover swards grow less herbage in early spring and late autumn, which can be made up by applying early and late small amounts of inorganic N fertiliser, but this is likely to reduce sward clover content.

- You can apply 50 kg N/ha bagged fertiliser N/ha in early spring and autumn to compensate for the growth habit of white clover, but don't go over this rate
- Red clover should never see inorganic (bagged) fertiliser N
- Some modern varieties of white clover are tolerant to inorganic N inputs, but they will fix less N if this approach is taken.

If significant and sustained contributions from clovers are required, the management focus needs to be on the clover. This means moderate inputs of organic manures are important, but using clover, manures and inorganic fertilisers together is difficult without compromising clover content.

- Apply the same amount of P and K as you would to a grass only sward (work out the correct requirement first of course)
- Red clover is particularly sensitive to compacted soils and waterlogged conditions, so make sure that soil condition is very good before you try growing red clover

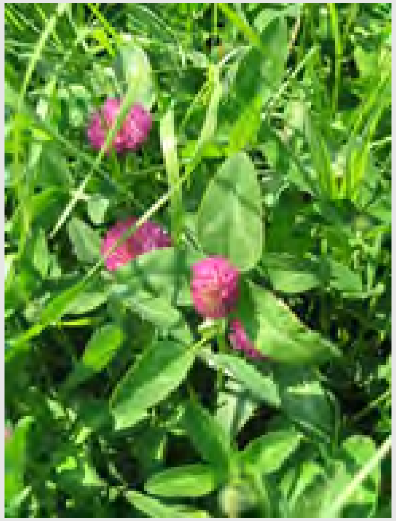
Summer

Establishing clover in an existing sward (over-sowing):

- Smaller leaved white clover varieties are better suited to hard continuous sheep grazing
- Medium leaved varieties suit frequent cutting and rotational grazing
- Large leaved varieties are suited for cutting and rotational grazing cattle systems
- Over-sow the seed early in spring or mid-season (after a silage cut) to minimise grass competition
- Control weeds adequately **before** sowing
- Reduce grass competition immediately prior to sowing by heavy grazing, or cutting for silage, and/or use a quarter dose of paraquat
- Place seed on or near soil surface and achieve close contact with the soil (by rolling or treading with grazing animals
- Stock heavily after sowing for a short period of time to control the grass during establishment
- Use about 7.5 kg clover seed per ha

White clover/grass mixed sward

Red clover/grass mixed sward



Sulphur

A deficiency of S will often show at this time of year, so if you don't already account for this nutrient in your management plan, consider the following:

- Sulphur is the fourth most important nutrient after N, P and K. Large amounts of S used to be deposited from atmospheric pollution and it was also in some fertilisers as an undeclared element
- Pollution levels have fallen dramatically and different fertilisers are more commonly used now. As a result deficiency is increasingly common on cereal, oilseed rape and grass, especially where cut for silage
- Addressing a deficiency will increase DM yield, but is likely also to increase herbage protein and sugar levels
- S deficiency may be seen as a paling or yellowing in the younger leaves of the plant
- S is most likely to be deficient on coarser textured soils or on younger swards, but atmospheric deposition is so low that a response is likely almost anywhere

Summer

Sulphur (continued)

- Herbage analysis will show whether S is deficient; an N:S ratio of >13:1 is usually considered deficient, but an S response may be seen at smaller ratios. Aim for a herbage S content of 0.25 to 0.4%

- Copper availability in the animal is unlikely to be a problem unless herbage S content is >0.4% and Mo (molybdenum) content is >4 mg/kg

- Use up to 40 kg/ha SO_3 per cut on silage, and modest dressings of an N:S fertiliser on grazing from late spring, which will supply 10-18 kg/ha SO_3 per application (or NKS fertiliser where K is required)

- S can be applied as bagged fertiliser combined with N and/or P and K in compounds or blends; and as Kieserite, gypsum, or elemental sulphur
  - Elemental sulphur is not immediately available to the plant
  - Gypsum as plasterboard waste and ground elemental sulphur require specialist spreading
  - Animal manures supply moderate amounts of S, but there is little useful information as to how available this is, and it is considered as supporting S reserves rather than supplying useable nutrient

Sodium (Na)

Salt is often said to be involved with the palatability of grass. The scientific evidence for this is very limited, but:

- Sodium (Na) is not critical to grass growth and only benefits yield and quality when K is deficient

- Although yield is not usually affected, there is some evidence that palatability can be improved by the application of Na, up to a level of 0.5% in the herbage DM

- Grass takes up nutrients in order of its requirements (N>K>Na>Mg>Ca), however, the mineral balance of Na, Mg and Ca is more important in the animal, for healthy function and to avoid disorders such as hypomagnesaemia (grass staggers) and milk fever

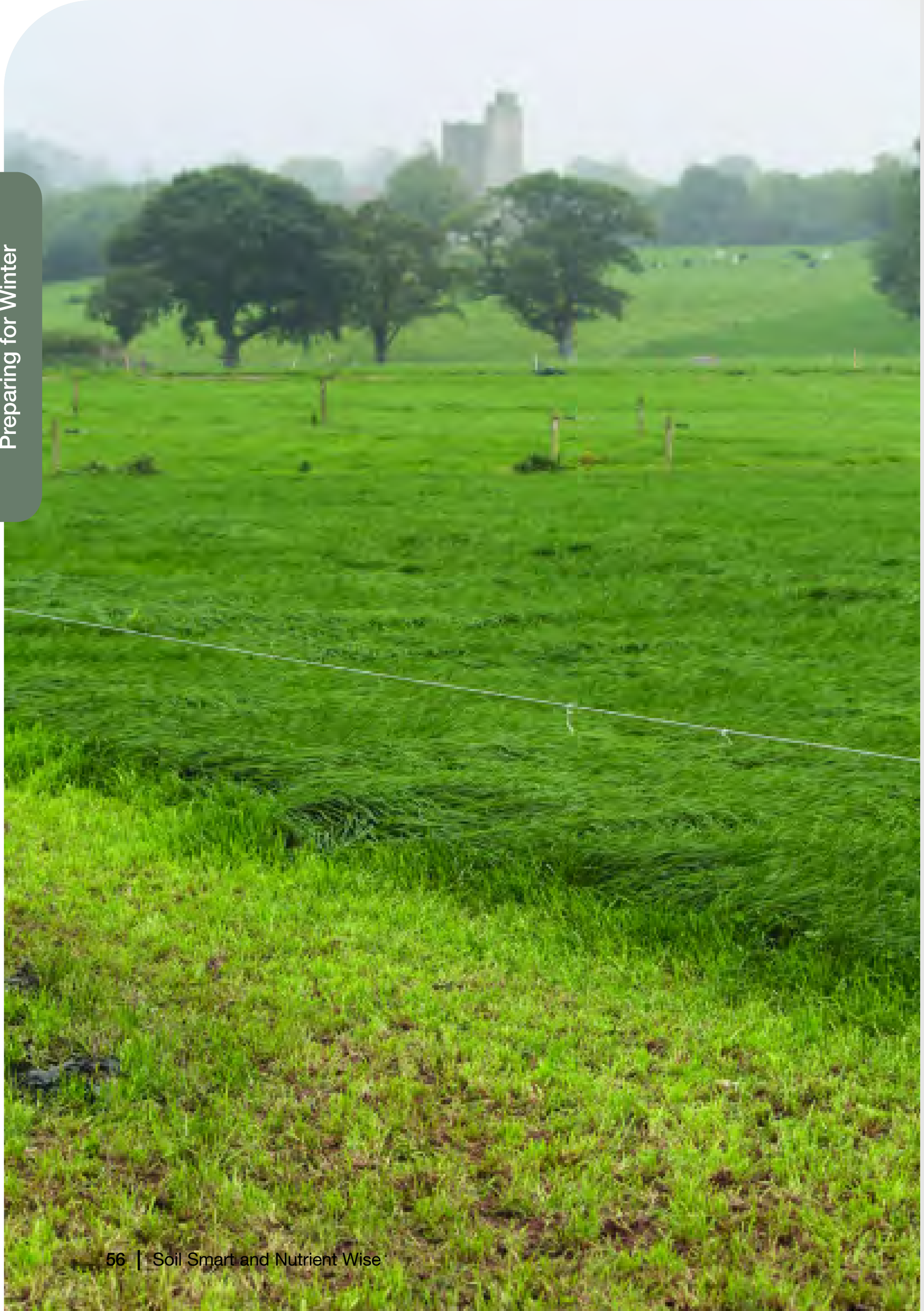
- It is often suggested that staggers results from high K coupled with low Mg in grass; however, there is evidence that suggests that a balance of Na, Mg and K is required

- The uptake of large amounts of K can reduce herbage concentrations of Na and Mg. The Mg should be at least 0.2% in the herbage DM, whilst Na should be at least 0.15%. The ratio of K:Na and K:Mg in the herbage should be no wider than 20:1

- Slurries contain appreciable amounts of Na and Mg, but the high levels of K mean that uptake may be limited. Sodium can be applied as bagged fertiliser, either agricultural salt, in more complex form as mined products such as Sylvinite, or as specialist manufactured compounds such as Grasstrac

- A common application rate to grassland would be 125 kg/ha (1 bag/acre) agricultural salt, supplying 62 kg/ha Na_2O (45 kg/ha Na) in spring or summer. Sodium is not well retained in the soil, so applications should be repeated each year.

Summer

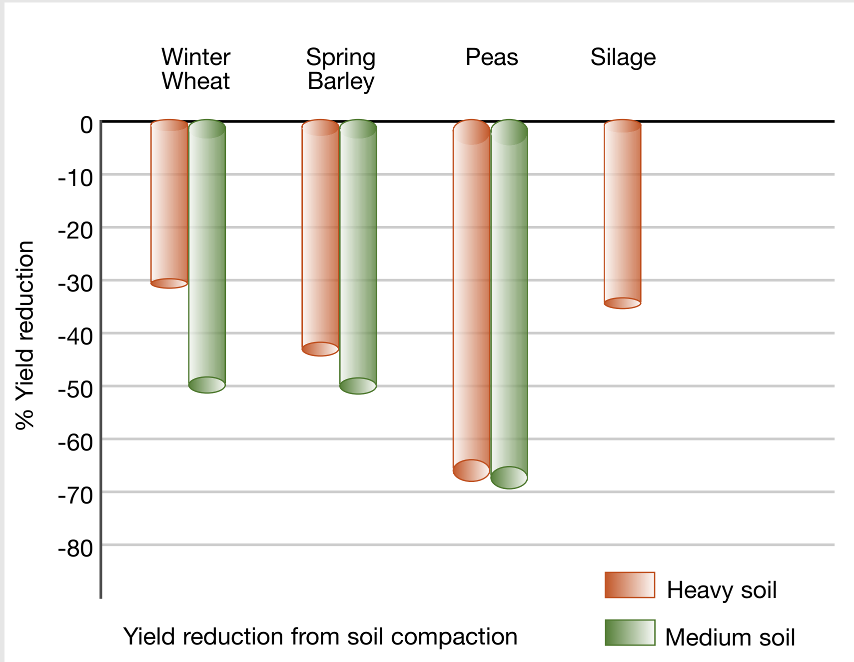


Preparing for Winter

Harvest

It is easy to damage soils at harvest with traffic wheelings and pressure on time to get jobs done; it's often the case that harvest happens when fields are a touch too wet – especially in late harvest crops like maize. The dangers here are:

- Loss of grass yield and quality from soil compaction.
- Compaction that reduces the success of autumn and spring sown crops, particularly those that are min-tilled and direct drilled.
- Reduced water infiltration due to surface compaction that leads to waterlogging.
- Run-off from soils that are surface compacted, leading to loss of soil and nutrients.



Picture left - Harvest soil compaction on a sloping field can lead to run-off

Preparing for Winter

Surface compaction after maize harvesting leading to waterlogging

Correcting soil compaction

Autumn is a good time to assess soil compaction and do something about it. Knowledge and action at this stage can improve grazing and sowing windows and set soils up for optimum grass and drop growth next year:

- Dig soil inspection pits to assess where compaction is
- Use spike aeration to alleviate surface compaction
- On harvested maize fields, consider using minimal surface tillage or harrowing to break up soil and allow water to pass through the soil – this will avoid waterlogging and run-off over winter
- Consider sowing a grass cover crop into fields that will not be sown until next spring; this will help avoid waterlogging and run-off and will provide forage for late autumn / early spring utilisation
- If you are going to plough, make sure that the plough is set to operate below soil compaction lower down the topsoil or subsoil profile, so that the compaction is eliminated in the process
- For compaction lower down the topsoil on fields that will not be ploughed, consider using a ‘sward lifter’ or ‘subsoiler’ to get rid of the compaction before winter sets in

Using a sward lifter / subsoiler

The improvements resulting from effective treatment by sward lifting/subsoiling should be seen in a matter of weeks and months, with improved grass growth (especially after spring treatment), better soil drainage and ground conditions for a longer grazing season. They can be used in an existing sward, although there will be some sward and soil surface disturbance, or when cultivating as part of a reseed.

When using a subsoiler it is important to note that:

- The critical depth of the subsoiler is important and the working depth must be 2.5cm below the compacted layer. Subsoiling below the critical depth can result in more compaction because of the sideways resistance of the surrounding soil and will require more power to drive the machine, increasing costs
- As a rule of thumb, the critical depth is approximately six times the individual loosening tines’ width, so a tine foot that is 8cm wide will have a critical depth of 48cm
- The higher the clay content, the less effective subsoiling will be
- If you subsoil when the soil is so wet that it is plastic (sticky), you will end up with a square mole channel and no heave in the soil
- If you are unsure about the critical depth, or are inexperienced in the operation, it is also wise to dig pits during the process to make sure that it is going to plan
- It’s worth considering subsoiling problem areas only, for example where compaction is resulting in standing water after heavy rain and around gateways, feeders and water troughs
- Carrying out these remedies when the soil is too dry may cause ripping of the soil

Sward lifters/subsoilers

Sward lifting when conditions are too wet leaves surface smearing

Successful sward lifting with no smearing

Cleaning up grassland and leaving a wedge

Regardless of your grazing system, try and graze down swards close to 3.5cm (1,500 kg DM/ha) at the last grazing – this will ensure minimal frost damage over winter.

- On rotational systems, leave a ‘flat-wedge’ across the grazing platform over winter, so that the swards that are closed up first are the ones to be grazed first next spring
- Assess sward composition at the end of the grazing season and decide if you need to take any remedial action by reseeding or stitching in poor areas by direct drilling:
    - Do you have more than 70% ryegrass in the sward?
    - If you need clover, do you have more than 30% clover content?

Grazing down to 3.5cm

Doing on-farm trials

If you are unsure about changing management (such as using an aerator) or using a product (like a fertiliser with an organic base), then it is worth trying the technique on a field and comparing the results with your normal practice. You can do this yourself, or as part of a group (local grassland society or discussion group) – we can all learn faster from pooling our experience and the results that the group gets.

On-farm trials are not science based, but they will grow your knowledge and understanding and give you confidence to make your own decisions. The things to remember when conducting your own trials are:

- Make the trial in one field – do not trial field against field as there will be differences that affect the result
- Make the trial in a field that is representative of the general soil and grass conditions on your farm
- Make the trial in a field that is relatively even and split the field equally between treatment and no treatment – for example, avoid having ‘with’ on a south facing slope and ‘without’ on a north facing slope
- Measure yield – e.g. use a rising plate meter in grazing paddocks or count trailers/bales in cut swards. This is important as a 10% difference in growth is impossible to see with the naked eye, but might be very significant to your system
- On cut swards, take representative samples of the cut grass to dry in the kitchen oven (weigh before and after oven drying) to get an estimate of DM yield (it is the DM that counts in the system, not the fresh weight)
- If part of the tested product advantage is supposed to be in grass quality, then take representative samples for laboratory analysis to test the theory

Last Section

On-farm trial of grass vs grass / white clover

Example areas that are conducive to this on-farm trial approach include:

- Soil enhancers (organic and humus based products)
- Soil conditioners such as aerators and sward lifters
- Alternative fertilisers such as seaweed based products, slow release products, and micronutrient containing materials
- Changing slurry application techniques, for example from splash plate spreading to injection
- New clover varieties that are nitrogen fertiliser tolerant
- Grass only vs grass/clover

You can measure the outcomes of different treatments by looking at:

- Soil condition through digging examination pits
- Soil fertility through analysis of pH, P, K, and Mg
- Grazed grass yield and intake by rising-plate measurements on grazing paddocks
- Conserved forage yield by weighing/counting trailers and big bales, and estimating dry matter in the kitchen oven
- Grass and silage quality by laboratory analysis

But when considering the results remember they can be dependent on the weather, seasonal variations and many interacting factors. So one season or one field might not give a repeatable result. This approach of on-farm trialling is more about managing risk by gaining confidence in a change, before spending money or causing problems by applying that change to the whole farm.

- Consider an on-farm trial before making big changes in management and product use
- Plan on-farm trials carefully to be as representative as possible and measure the impacts as accurately as you can

Environmental issues

The main things to be aware of and take action on when considering soil and nutrient management and the environment are:

- Soil compaction can lead to loss of soil and nutrients in run-off
- Not following the Code of Good Agricultural Practice and/or Nitrate Vulnerable Zone (NVZ) regulations when managing soils, fertiliser and organic manures can lead to diffuse pollution of surface and groundwaters, particularly with N and P
- Over applications of nutrients will lead to build up in soil and increased risk of loss to air and water (it's also expensive in terms of wasted costs).

Basic soil and nutrient management tips for protecting the environment:

- Keep soils in good condition, with pH at 6.5, P, K and Mg status at index 2 and avoid compaction in the soil structure
- Where you have compaction, deal with it (it'll help your system to be more efficient as well as reduce the risk of nutrient losses to the environment)
- Don't apply nutrients in the wrong conditions (too wet/dry, too early/late, in frost, etc.)
- Use the right nutrient source at the right time (e.g. urea vs ammonium nitrate, inorganic vs organic fertilisers)
- Leave buffer strips round the edges of fields – don't apply nutrients right up to the field edge
- Fence off surface water from cattle
- Consider using buffer strips at the bottom of sloping fields if they run into ditches, streams and rivers
- Make sure the farm has a manure spreading risk map, with all the hazards (boreholes, streams, ditches, etc.) marked and brief all staff on how to use the map to avoid losing nutrients to the environment
- Make sure that your Soil Protection Review is 'real' and up to date (it's part of Cross Compliance)
- Make sure you have adequate slurry and manure storage so that you can use it in the growing season when grass and crops can make best use of the nutrients
- Have separate clean and dirty water handing systems – this will reduce the number of slurry applications you have to make
- Review concrete/yard areas to make sure that you minimise dirty water and reduce run-off

✖ Cattle grazing and poaching land next to an unfenced stream

✔ Water ditch fenced off from cattle

✖ Uncontrolled clean water from roofs will create dirty water

✔ Stock fencing leaves a stream free from nutrient pollution

✖ Algae grow in streams when nutrients from slurry are not controlled

✔ Good hard standing around water troughs prevents compaction and pollution

✖ Soil compaction around a water trough close to surface waters will lead to soil and nutrient losses

✔ A low input buffer strip on slopes leading to water courses will protect them from nutrient loss

✖ It's easy for uncontained run-off from FYM middens to reach water courses

✖ It's easy for nutrients to be lost from poorly maintained yards

Farming within NVZ regulations

If you are farming in an NVZ, you need to comply with the regulations and pay particular attention to:

- Farm nutrient-management planning
- Keeping up to date and complete records
- Not farming with a slurry/manure N loading that exceeds to 170 kg total N/ha (or 250 kg total N/ha if you have a derogation)
- Not applying more N than the N max limit for the crop to be grown
- Having enough slurry and manure storage to comply with closed periods for spreading
- Closed periods for manufactured inorganic N fertilisers

The NVZ area has been expanded (particularly in England) and regulations have been tightened further as from January and May 2013. So, if you need to check if you are farming in an NVZ or what the rules are, there are maps on the DEFRA website and guidance leaflets available at

https://www.gov.uk/nitrate-vulnerable-zones and
http://archive.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/help-for-farmers.htm

The most important things to consider and do are:

Record keeping

In everything done to meet NVZ regulations, keep records. These must be in an easily accessible form for inspection and kept for at least five years. If in doubt keep it and this applies to all calculations, nutrient management plans, implementation of plans and operations on a whole farm and individual field basis.

There are software options that can help, for example the PLANET programme for nutrient management planning and DairyCo's Slurry Wizard for working out storage requirements. Make sure that you keep electronic copies if you are using computer software to help you.

Work out your storage requirements

You must provide at least:

- 5 months storage capacity for cattle slurry (1 October to 1 March inclusive)
- 6 months for pig slurry and poultry manure (1 October to 1 April inclusive)

The DairyCo Dairy Wizard (containing the 'Slurry Wizard' program) will help with this.

Livestock manure N farm limit

There is a 'loading' or stocking rate limit over the farm so that applications of livestock manure shall not exceed 170kg total N/ha in any calendar year. Livestock farmers with at least 80% grassland can apply for derogation to 250kg total manure N/ha. You should use the standard livestock N output values (leaflet 3 of the DEFRA guidance pack, or use the DairyCo Slurry Wizard) to make the calculations.

Organic manure N field limit

No more than 250kg total manure N can be applied to a field in any calendar year. This figure:

- Excludes excreta from grazing stock
- Includes sewage sludges, composts, industrial wastes, etc.

Closed periods for spreading organic manures

For organic manures with a high readily available N content (like cattle slurry, pig slurry and poultry manure) do not apply in the periods shown below:

Grassland		Tillage land	
Sandy or shallow soils	All other soils	Sandy or shallow soils	All other soils
1 Sep – 31 Dec	15 Oct – 31 Jan	1 Aug – 31Dec*	1 Oct – 31 Jan

*Application between 1 August and 15 September allowed provided a crop is sown on or before 15 September

Individual application limits

Do not apply more than 50 m3/ha slurry or 50t/ha solid manure in one application and do not return with further dressings for a minimum of three weeks, up to the end of February. For some of the original NVZ areas, the limit is now 30 m3/ha – check the websites quoted above for details.

A 25m3/ha cattle slurry splash plate application on grassland

A 50m3/ha cattle slurry splash plate application on grassland

A 25 tonnes/ha cattle FYM application on grassland

A 50 tonnes/ha cattle FYM application on grassland

Closed periods for applying manufactured N

Do not apply inorganic manufactured N:

- On grassland between 15 September and 15 January
- On tillage between 1 September and 15 January

Do not apply outside these dates, unless you have written justification and advice from a FACTS (Fertiliser Advisers Certification and Training Scheme) qualified adviser.

Crop N requirement limit (N max)

Different crops cannot receive more than a maximum limit of N (N max), derived from crop available N in organic manures and N from inorganic manufactured fertilisers. You should also account for N from soils reserves (soil nitrogen supply – SNS) to make efficient use of all N sources.

N max limits

Crop	N max limit (kg N/ha)	Standard crop yield (t/ha)
Grass	300*	N/A
Forage maize	150	N/A
Wheat, autumn or early winter sown	220	8.0
Wheat, spring sown	180	7.0
Barley, winter	180	6.5
Barley, spring	150	5.5
Oilseed rape, winter	250	3.5
Peas	0	N/A
Beans	0	N/A

*An extra 40kg N/ha (i.e. 340kg N/ha in total) is allowed for grassland that is cut at least 3 times per year.

For each field

You have to calculate and justify the N requirement according to the crop to be grown. Make sure you consider:

- Soil N supply (SNS)
- N requirement of the crop
- Allow for supply of crop available N from organic manures
- Only plan to apply inorganic manufactured N to fill the gap between crop requirement and SNS plus N from organic manures – not exceeding the N max limit

Also, make sure that you do not exceed the N max limits, even if the standard recommendation tables suggest that the crop requires more N, although such a situation will be rare.

Across the farm

Make sure N applied to the whole area of the crop type (as kg N/ha) does not exceed the N max limit for the area, accounting for manufactured N plus crop available livestock manure N.

Spreading restrictions

No organic manure spreading is permitted:

- Within 50 m of a spring, well or borehole or 10 m from a surface water
- On waterlogged, frozen, snow covered or flooded land
- No nitrogen fertiliser (inorganic manufactured or organic manure) can be applied to steep sloping land (12 degrees or more), where there is a risk of causing pollution.

Complying with the regulations

Do not forget that:

- The NVZ regulations aim to reduce pollution of water
- Abiding with the regulations will help to improve the efficiency of N use on your farm, reducing the requirement for purchased inorganic N
- All of the elements within the NVZ regulations can be incorporated into your farm NMP that should anyway be the basis of a way of thinking to optimise performance

Get more information:

Useful sources and links for soil and nutrient management

Information on **soils and nutrients for grassland farmers** free from **http://www.britishgrassland.com**

Basic nutrient management planning, including work sheets and record sheets free from Tried & Tested at **http://www.nutrientmanagement.org**

Official **PLANET software for nutrient management planning and NVZ** compliance free from **http://www.planet4farmers.co.uk**

Information on **NVZ regulations and compliance** free from **https://www.gov.uk/nitrate-vulnerable-zones** and **http://archive.defra.gov.uk/environment/quality/water/waterquality/diffuse/nitrate/help-for-farmers.htm**

Information on **soil management** free from **http://www.ahdb.org.uk/projects/documents/ThinkSoils.pdf**

The official DEFRA RB209 **Fertiliser Manual** is available free at **https://www.gov.uk/government/publications/fertiliser-manual-rb209**

Phosphate and potassium information and calculators are available free from **http://www.pda.org.uk**

Information on **liming materials** and a liming calculator are free from **http://www.aglime.org.uk**

FACTS qualified nutrient advisors can be found at **http://www.basis-reg.com/map/uk.aspx?map=factsadvisor**

Last Section

Farmer Directed Demonstration - Examples

This section provides groups, local grassland societies and individual farmers so guidance on setting up their own trials/demonstrations. This is type of approach is not intended to be scientifically robust but aims to provide discussion and answer questions relevant to the group or individual farm,This is not an exhaustive list but is intended to cover the topics that Nutrient Wise Demonstration Programme covered in the period 2010-13.

The British Grassland Society cannot provide financial support or be held any way liable for outcomes of any particular group/individual participating in the trials. The Society would urge participants to refer to RB209 for Fertiliser Recommendations, if in doubt seek advice from a FACTS qualified adviser; operate within Cross Compliance and GEAC requirements; comply with NVZ regulations and any Agri-Environment Schemes applicable to the farm(s) where the trials/demonstrations are being conducted.

Please remember to look after your own safety and those visiting the site.

1. Liming Materials

Step 1. Identify fields with a low pH through soil testing (more on page 17) Once fields with low pH are identified, select a field which can be easily divided into 5.
Optimum pH for grass with occasional wheat or oat crop or a continuous grass or grass/clover swards is 6.0
Optimum pH for grass with occasional barley crop is 6.2

Step 2. Divide the field into up to 5 strips, the wider the better, for ease of spreading and to make sure there is enough space in the centre of the strips where soil can be sampled in twelve months' time that hasn't been contaminated by neighbouring strips. You will need to measure the size of these strips to work out how much of the liming material you will need to order.

Step 3. Choose 4 liming materials (or if you only have 4 strips, choose 3, 3 strips choose 2) that have been recommended by your FACTS Advisor, merchant, discussion group buying group, or you are interested in trialling.
Always refer to RB209 for more detailed information

Using the known area of the strips, order the required amount of each product plus some extra just in case application doesn't go to plan.

Examples of liming materials we recommend to try:
- Calcium Carbonate
- Ground or coarse mag lime
- Ground or coarse limestone

Step 4. Apply the 4 liming materials to the strips and mark on the map in figure 1 where each was applied. The 5th strip needs to be left alone as a control so any natural decrease in pH in the next twelve months can be measured

Step 5. Treat the field as normal through your grazing, fertilising, and cutting practices for the next twelve months. Leave markers on the fence lines so you know where each strip ends and begins to help you with measuring later on.

Bonus step: If you are interested in the level of grass growth in each of the strips, you can plate meter the areas individually and record the growth.

Step 6. At the end of the 12 month period, soil sample each of the strips, keeping away from the edges. The pH increase against the first samples and against the control block will help determine which liming method was most effective for your soil. Also while recording the biggest increase in soil pH,you should also calculate the rate of increase against the cost. This will determine if the liming materials was also the most cost effective at the same time as its ability to increase pH in the twelve month period.

Step 7. Recording the strips again at the 24 month mark will also give you an indication of the length of time and effectiveness of some slower acting liming materials.

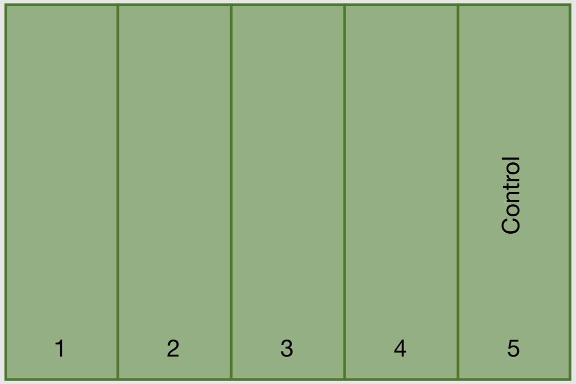


Figure 1 example (liming materials)

2. Aerator vs Subsoiler

Soil compaction at different heights is an issue on many farms across the UK and advice and which method, using an aerator or a subsoiler for example, can be conflicting from different parties. What suits your soil is entirely dependent on the depth/cause of the compaction in your soil on your own farm and your own soil type.

Step 1. Identify fields with compaction problems through digging a hole in the centre of the field away from gateways, troughs, and fence lines. Fields to dig holes in may have been underperforming in grass and crop production, had been poached during poor weather, or tractor/machinery damage. For more on digging a hole see page XX Take pictures of the compaction for reference later on.
Step 2. In the autumn, divide the field into three sections and mark on the fence line, and down the strip for the contractor to show which section is to be allocated to each part of the trial.
Step 3. Measuring the depths of the compaction with your contractor, get them to run strips up and down the field with the subsoiler in its allocated half at the correct depth and measure that the depth is correct after the first half run to make sure its correct. Repeat the process with the aerator in the aerators half of the field.
Step 4. From late January begin to measure grass growth in the fields the three sections by plate meter for the duration of the spring. Make sure you avoid the edges where there may be some cross over
Step 5. Before silaging time but after the field has had a couple of grazings, dig holes again in the two halves to see if the compaction has been improved or changed at all.
Step 6. Using the grass growth data and the difference in compaction at the beginning to the end of the trial to see which was most effective in your trial.

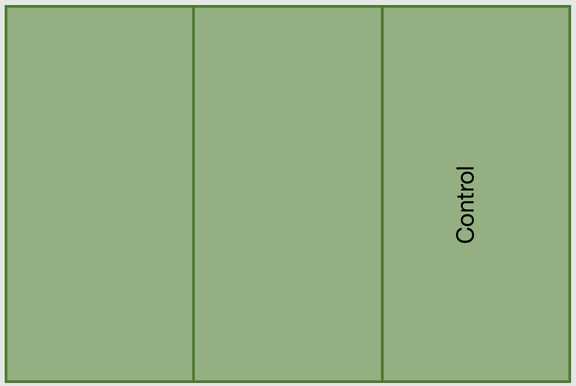


Figure 2 example (aerator vs sward lifter)

3. Injecting slurry vs splash plate spreading

Research into injected slurry as an alternative to splash plate spreading is looking at not only the environmental benefits but any grazing preferences and of course, any advantage in grass growth between the different methods.

Step 1. dentify a field you wish to spread slurry on. Make sure this complies with any NVZ regulations on your farm. Divide this field into two even halves and mark on the fence line to identify later on. You may also want to identify the halfway point down the length of the field for the person spreading/injecting the slurry. Fill in figure 3 with which side of the field is which for later reference
Step 2. Allocate equal amounts of slurry to the two methods and inject in the allocated half and splash plate spread in the other. Take a picture of the ground immediately after spreading/injecting on each half to compare later.
Step 3. Measure and record grass growth in each half fortnightly throughout the season. Remember to avoid the edges where cross over may have occurred. Continue to treat the field as normal during this period and continue to apply the fertiliser you regularly would. You may want to also watch cows grazing behaviour on the field for the initial few grazing periods and record any preferential grazing.
Step 4. Using the data you have collected on grass growth and any findings on cow grazing preferences, use the demonstration to determine which method you prefer. You may also want to compare the cost per ha of the two methods which may help determine your preference.

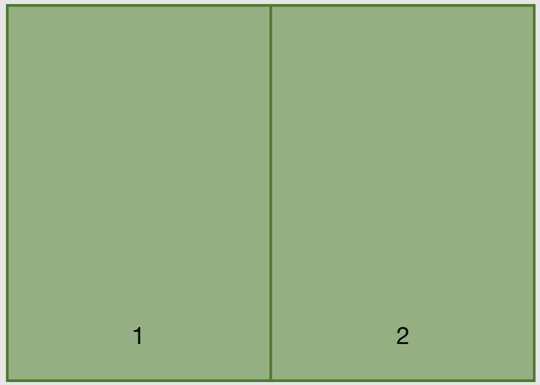


Figure 3. Injected slurry vs splash plate spreading

4. Organic Manure Options

There are many different types of organic manures available but it comes down to farmer choice and preference as well has how cost effective each of these options is per ha.

Which organic manure to choose

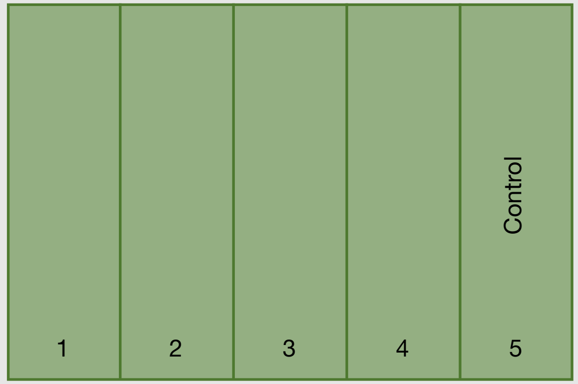
Availability depends on location and type of farming as to which products are available. Remember to take account of crop nutrient requirements, some are a good source of crop available nutrients, some release nutrients as they break down over time but act as a soil conditioner.

In general organic material that has been composted acts as a soil conditioner and has useful quantities of phosphate and potash available in the first year but nitrogen availability in the first is very low. In contrast, organic materials that havebeen subject to anaerobic digestion have high available nitrogen quantities in the first year as well as useful quantities of phosphate and potash.

- Some wastes are approved for use on organic farms
- Restrictions, recording requirements and Environment Agency approval differ for different products.

Step 1. Select up to 4 different manures you would like to use. Some suggestions from the British Grassland Society are:
- Well- rotted farm yard manure (FYM) (12 months old)
- Ordinary Farm Yard Manure (straight from the shed or only stored for 6 months)
- Green waste compost to PAS 100 standard
- Pelleted Poultry litter

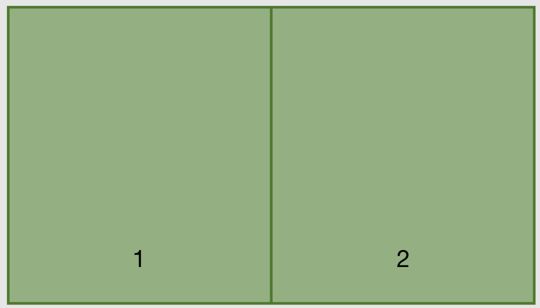
Step 2. Identify your field you would like to run your demonstration on and divide into sections based on the number of manures you choose plus one. Mark on the fence line where each plot begins and ends and along the strip for the contractor’s reference while spreading the manure. Record the allocated manure to which strip in figure 4 below.
Step 3. Spread the recommended amount of manure in the recommended spreading method on each section. Take photos after spreading for comparison later on.
Step 4. Monitor how long the manure takes to break down, and the grass growth for the rest of the season. You may also want to record any grazing preferences between the different strips.
Step 5. Compare your data on grass growth, manure break down, cost of the manure and spreading, and any grazing preferences to draw conclusions on the manure that worked best for your system.



5. CAN vs Urea

This is a trial we have worked on before in a DairyCoDemonstration. CAN and Urea will behave differently when applied at different times of the year. This will involve applying small amounts (around 30kgN/ha) every grazing round.

Step 1. Identify your grazing field and divide evenly in two, marking down the middle for the contractor to spread and mark on the fence lines for future reference. Measure each section and set aside enough of each fertiliser to make sure both halves receive 250kgN/ha during the trial.
Step 2. Apply the first 30kgN/ha of each of the treatments to the halves and begin to measure grass growth. From now also keep a record of temperatures and rainfall. Record which side is which in figure 6 below.
Step 3. After each grazing round apply another 30kgN/ha until the 250kg allocated to each side is used. Remember to treat both sides as you would normally within normal farm practice.
Step 4. Using the grass growth data, model the differences in grass growth according to date to see if there is any difference at different periods of the year and if this is related to weather or the temperatures.



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