11 Optimising fertiliser practice

Objective:

- To integrate all available fertilisers into a cost-effective management programme, optimising pasture growth for when it's required.

Challenge:

- Ensure your swards have the right pH and P & K status
- Achieve a better balance between your N inputs and offtake
- Identify ways to reduce your fertiliser bills and make better use of clover.

What's in this section?

- **Managing soil pH and P & K status**
- **Valuing the N contribution of clover**
- **Understanding the N contribution of organic manures**
- **Balancing N inputs and offtake.**

Target

Improve the cost-effectiveness of fertilisation, reducing N use by at least 10%.

Better Fertiliser Management

Targeted and efficient use of fertilisers is recognised as one of the best ways of ensuring the right levels of pasture production at the required times for grazing and conservation.

Within most grassland systems purchased fertiliser cost savings in excess of £200/ha have been found to be possible if full account is taken of the contribution of N, P and K from FYM, slurry and other organic manures.

Further worthwhile savings are possible through more effective utilisation of clover in swards (**Section 10**).

Contents

All recommendations in this chapter are in line with the 2010 8th edition of RB209. The Defra RB209 Fertiliser manual can be obtained from The Stationery Office at www.tsoshop.co.uk or as a free download at www.defra.gov.uk/rb209

Soil acidity

Maintaining the correct degree of soil acidity helps grassland productivity by ensuring better earthworm and soil bacterial activity, optimising nutrient uptake and release and encouraging prolific grass and clover growth.

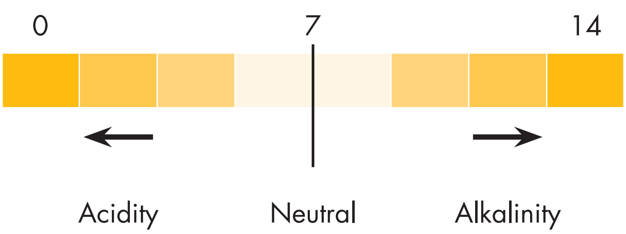
On the pH scale of 1-14 (Figure 11.1) the best grass growth in established grassland on most soil types occurs at around pH 6.0.

If clover is to be maintained in the sward, then the pH needs to be 6.0-6.5.

Below these levels the acidity of the soil can be rectified by liming.

Soils with high organic matter content and peaty soils have lower pH thresholds before liming is necessary.

Figure 11.1: The pH Scale



In addition to calcium, major elements like magnesium, potash and sodium also contribute to the pH status of the soil.

This means a pH 6-7 soil can still be calcium-deficient if the status is maintained by other elements.

Assessing Soil Acidity

As a quick check, acid soils (pH 6 or below) are characterised by:

- Poor dry matter production
- Few earthworms
- Poor clover growth
- Matted grass
- Weed grasses such as Yorkshire fog and creeping bent
- Areas of gorse, bracken, foxgloves and sorrel.

Soil sampling and analysis are essential to measure pH accurately.

Core soil samples for analysis should be taken with an auger to a depth of 10cm (4”).

Any surface organic matter should be excluded from the sample.

Care should be taken not to mix individual cores from dissimilar areas.

Analysis is best carried out alongside assessments of soil P and K status.

Where soil type is known to vary within a field, separate areas should be sampled.

Suitable augers and guidance on sampling are available from most analysis providers.

Rectifying Soil Acidity

Most swards should be maintained with a pH in the range 6.0-6.5.

Liming of established swards is recommended when values are less than pH 6.0.

For new reseeds liming should be undertaken at pH 6.4 and below; after ploughing, not before.

In order to prevent trace element lock-up and reduced microbial activity in the medium term (over 6-12 months) grassland liming is best limited to one tonne/acre (2.4 tonnes/ha) per application.

This may be reduced to 2 tonnes/ha, but application rate will depend on the liming material. For better quality material this will be sufficient, but low neutralising value materials will need a higher rate to be effective.

The more acid the soil (lower pH), the more lime applications will be needed to lift the pH, although applications should never exceed one tonne/acre/year (2.4 tonnes/ha).

If soil magnesium levels are at index 2, avoid using magnesium-based limes.

A wide variety of liming materials with a range of neutralising values are available through specialist suppliers or general contractors.

Factsheet 8 provides details of liming materials and applications.

P and K status

Sufficient phosphate (P) and potash (K) are essential to sward productivity.

Poor overall sward growth is a symptom of insufficient P, while a shortage of potash shows up in a lack of growth, vigour and persistency in ryegrasses and clovers, and the replacement of ryegrasses by other species more tolerant of a lower K status.

Dung and urine patches show up as dark green areas within a pale green sward.

Levels of P and K in the soil depend on the balance between the minerals removed through grazing and conservation and those returned through dunging and farmyard manure or slurry applications.

Background P and K status is indicated by indices established through soil analysis.

Maintaining P & K Status

Soil samples should be taken in the same way as for pH analysis, ideally every 3-4 seasons.

Analysis results should be considered against established application guidelines (**Tables 11.1 & 11.2**).

Sandy soils have little reserves of potash but clay soils can provide around two thirds of annual crop requirements.

P and K indices of 2 are the target for the most productive grass swards.

For mixed grass/clover swards the indices should be kept at 2-3.

A K index of 3 or above requires special attention to stock because potash can interfere with magnesium uptake.

To avoid the possible interference of magnesium uptake by K, do not apply K fertilisers to grazed grassland in spring, unless the soil K status is below index 1.

Factsheet 7 provides information on magnesium requirements at grass.

Table 11.1 Phosphate and Potash Recommendations for Grazed Swards (total for the whole year)

	Soil P or K Index			
	0	1	2	3
	Dressing required (kg/ha)			
Phosphate (P_2O_5)	80	50	20	0
Potash (K_2O)[b]	60	30	0	0

Table 11.2 Phosphate and Potash Recommendations for Cut Swards*

	Soil P or K Index				
	0	1	2	3	4 and over
	Dressing required (kg/ha)**				
1st cut (23 tonnes/ha)* **					
Phosphate (P_2O_5)	100	70	40	20	0
Potash (K_2O)[b]					
– previous autumn	60	30	0	0	0
– spring	80	80	80 (2-) 60 (2+)	30	0
2nd cut (15 tonnes/ha)					
Phosphate (P_2O_5)	25	25	25	0	0
Potash (K_2O)[b]	120	100	90 (2-) 60 (2+)	40	0
3rd cut (9 tonnes/ha)					
Phosphate (P_2O_5)	15	15	15	0	0
Potash (K_2O)[b]	80	80	80 (2-) 40 (2+)	20	0
4th cut (7 tonnes/ha)					
Phosphate (P_2O_5)	10	10	10	0	0
Potash (K_2O)[b]	70	70	70 (2-) 40 (2+)	20	0

** Account should be taken of P and K applied in organic manures*
*** Dressing of available P*
**** Yields are in fresh weight and are indicative to calculate offtakes of nutrients that need to be replaced by fertiliser applications*

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

Meeting Seasonal P & K Needs

Phosphate and potash fertilisation needs can be assessed on a seasonal basis from estimates of the amounts of the minerals removed through grazing and conservation and returned through dunging and farmyard manure or slurry applications (**Table 11.3**).

Attention needs to be paid to the availability of any fertiliser or organic phosphate supplied.

The direct return of P and K through dunging means grazing depletes soil reserves relatively slowly, requiring no, or only modest levels of annual fertilisation on grazing swards.

In contrast, an early season cut of 6 tonnes silage DM/ha removes about 40kg/ha of phosphate and about 140kg/ha of potash.

A full season of three or four silage cuts typically removes 80-100kg/ha of phosphate and around 325kg/ha of potash.

For silage swards, 0.15kg of phosphate and 0.5kg of potash/ha should be applied for every kg of N used.

Table 11.3 Typical P and K Content of FYM and Slurries

	DM%	Total Nutrients (kg/m^3 or tonne)		Available Nutrients (kg/m^3 or tonne)	
		Phosphate	Potash	Phosphate	Potash
Solid Manures					
Cattle FYM	25	3.2	8.0	1.9	7.2
Pig FYM	25	6.0	8.0	3.6	7.2
Layer manure	35	14.0	9.5	8.4	8.6
Poultry litter	60	25.0	15.0	15.0	18.0
Slurries/Liquids					
Dairy	6	1.2	3.2	0.6	2.9
Pig	4	1.8	2.4	0.9	2.2
Dirty water	0.5	0.1	1.0	0.05	1.0
Separated cattle slurries (liquid portion)					
Strainer box	1.5	0.3	2.2	0.15	2.0
Weeping wall	3	0.5	3.0	0.25	2.7
Mechanical	4	1.2	3.5	0.6	3.2

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

Timing P & K Applications

Applications of P should be applied in early spring as P is vital for root development and applied as MAP (or other available P source).

On balance, spring application is to be preferred to later in the season, with ammonium phosphate becoming increasingly popular for grazing land.

One application of phosphate per year is generally sufficient or, with some materials, one every two or three years.

Two or three annual applications of potash are the norm in grassland as larger dressings lead to excessive uptake by the sward and waste in silage or urine patches.

To minimise the risk of hypomagnesaemia, potash should not be applied in the spring unless to severely deficient pastures (indexing less than 1).

Wherever potash is required it is best applied in mid-season or the previous autumn.

Sodium and magnesium

Reasonable levels of sodium and magnesium should be maintained alongside potash to safeguard sward palatability.

Further information is available in the Potash Development Association (PDA) Leaflet 6, and at www.pda.org.uk

Magnesium deficiency is not thought to affect the growth of grass or clovers, but a shortage in the herbage can predispose stock to hypomagnesaemia, particularly where potash levels are high.

Magnesium fertilisation is unlikely to be needed on a regular basis.

Magnesium supplements should always be provided to stock at risk of hypomagnesaemia.

Factsheet 7 provides information on magnesium requirements at grass.

N recommendations

The level of fertilisation required by grassland depends on its soil nitrogen supply (SNS) status, the growth potential of the land, termed the 'Grass Growth Class' and the level of production of the system. Balancing these elements means that the N applied to grass can be tailored to make the most efficient use of the soils for the desired level of production; essentially growing the right amount of quality grass to meet the energy and protein demands of the cows.

Table 11.4: Grassland SNS Status and Previous Management

SNS Status	Previous Management	Previous N Input *
High	Long-term high-input grassland, including grass re-seeded after grass or one-year arable, and second or subsequent year leys.	Over 250kg/ha
Moderate	First year ley after two or more years arable (last crop potatoes, oilseed rape, peas or beans not on light sandy soil).	All regimes
	Long-term moderate input grassland, including grass re-seeded after grass or one year arable, and second or subsequent year leys.	100-250kg/ha or substantial clover content
Low	First year ley after two or more years arable (last crop cereals, sugar beet, linseed or any crop on light sandy soil).	All regimes
	Long-term low input grassland, including grass re-seeded after grass or one year arable, and second or subsequent year leys.	Up to 100kg/ha

** Typical fertiliser and manure N use in the last 2-3 years.*

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

Most intensively managed pasture has a high soil nitrogen supply status as a result of dung and urine returned to the soil during grazing and/or the application of organic manures.

It is important to also assess the Grass Growth Class to get an idea of the potential response of grass to nitrogen fertilisation.

Table 11.5 Grass Growth Class

Soil Available Water	Soil types	Rainfall* (April to September inclusive)		
		up to 300 mm	300 – 400 mm	over 400 mm
Low	Light sand soils and shallow soils (not over chalk)	Very poor	Poor	Average
Medium	Medium soils, deep clay soils, and shallow soils over chalk	Poor	Average	Good
High	Deep silty soils, peaty soils and soils with groundwater (eg river meadows)	Average	Good	Very good

**Mean summer rainfall (April to September) is usually about half of annual rainfall.*

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

Applying N to Grazed Grass Swards

Nitrogen fertiliser should be applied to stimulate early season growth and then every time the pasture has been grazed down to the post-graze point during the spring/summer (**Table 11.5**).

It is important that the total annual application does not exceed the maximum recommended amount.

Excessive nitrogen applications can result in severe health problems in grazing livestock and adversely affect fertility.

Table 11.6 Total annual N Requirement Recommendations for Dairy Cow Grazing (kg/ha)

Milk Yield (litres/cow/year)	Concentrate use (tonnes/cow/year)	Stocking Rate (LU/ha)	Grass Growth Class	
			Very good/Good	Average
8,000 to 10,000	4.4	4.0	280	290
		3.5	210	210
		3.0	150	170
8,000 to 10,000	3.7	3.0	300	290
		2.6	210	240
		2.2	150	200
6,000 to 8,000	2.2	2.6	320	340
		2.2	210	260
		1.8	140	180
6,000 to 8,000	1.5	2.2	340	340
		1.8	210	240
		1.6	170	190
6,000 to 8,000	0.9	1.9	320	340
		1.7	240	240
		1.5	190	180
4,000 to 6,000	0.9	2.4	330	330
		2.1	240	250
		1.8	180	200
4,000 to 6,000	0.5	2.1	290	330
		1.9	230	240
		1.7	190	190
<5,000	0.5	2.5	340	340
		2.2	240	250
		2.0	200	200

The recommendations recognise that good grass growth sites produce more grass at the same fertiliser N input; thus, in some systems, growing grass on an average site takes more fertiliser N than on the same system on a good Grass Growth Class site.

Values in the above table are total annual requirement for moderate SNS. To obtain an applied inorganic fertiliser requirement, add 30kg N for low SNS situations, subtract 30kg N for high SNS situations and account for the contribution of clovers and organic manures.

Stocking rate is based on all dairy animals (in-milk cows, dry-cows and followers) where 1 cow = 1 LU.

To get an N requirement between stocking rates at the same milk yield/concentrate use combination, assume a proportional difference between the two values.

To get an N requirement between concentrate use at the same milk yield/stocking rate combination, add (subtract) 10kg N for every reduction (increase) of 0.1 tonnes concentrate/cow/year.

Split applications (approximately six over the season) to match the cutting pattern. For example, the recommended split of N application might be: for first cut – 40% (split further 15% Feb-Mar + 25% Apr); for second cut – 35% (could be split further 20% May + 15% Jun); for subsequent cuts – 25% (could be split further 15% Jul + 10% Aug).

In dry summers, reduce the mid-season application(s) if growth in the previous month has been restricted.

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

Reducing N application by 25% will only reduce pasture yield by 10%, and reducing the application by 50% will reduce pasture yield by 20-25%.

Even with fertiliser prices as high as 80 to 90p/kg N, the responsiveness of a pasture to N is more important in determining the cost of spring grass than the price alone (**Table 11.7**). In terms of the cost of grazed grass, reducing the response rate from 10 to 6kg DM grass per kg fertiliser N is the same as raising the fertiliser price from £207/tonne 34.5% N fertilisers to £345/tonne. Therefore, managing the soil and grass to get the maximum response is critical to the cost of the cheapest feed available on most farms – grazed grass.

Even with a low response rate of 6kg DM/ha, N fertilisation to boost intake from grass is a cheaper option than silage and compound feed.

Table 11.7 Spring Grass Costs (p/kg)

Response Rate (kg grazing DM/kg N)	N Cost (p/kg)		
	60	80	100
6	10	13	17
8	7.5	10	12.5
10	6	8	10

Source: Based on IGER Grassland Technology Transfer, Fertiliser for Spring Grass 105.01 and updated for fertiliser price.

As well as the total application rate, the following considerations are important in optimising N fertilisation:

- Initial application timing
- Final application timing
- Application frequency
- Fertiliser type
- Nitrate Vulnerable Zone (NVZ) requirements.

Initial Application Timing

T Sum 200°C – defined as the point at which the sum of the average daily temperature above 0°C since 1 January reaches 200°C – has been found to be of limited value as a guide to the timing of the first N application because of high year-to-year variations.

There is a 2-5 week period in which applications will produce grass yields of above 90% of potential and on most farms the T Sum 200°C will fall within this period.

In practice, the first N application should be made when soil temperature reaches a minimum of 5°C at 10cm depth on three consecutive days and ground conditions permit – usually from mid-February onwards (early March for northern England and Scotland).

Final Application Timing

To avoid pollution from nitrate leaching it is recommended that no N applications are made after mid-August and that early August applications are limited to 50kg/ha.

Application Frequency

The pattern of grass growth can be manipulated by the amount of N supplied at different times of the season (**Figure 11.2**).

N applications should be planned to the required grass growth and sward budget (Section 4).

As a rule of thumb 20-30kg DM is produced for each kg N applied up to 300kg/ha/year.

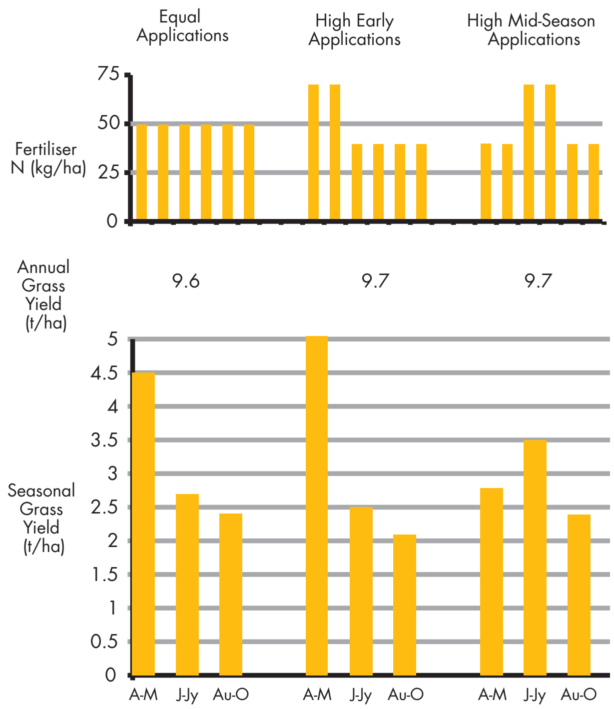
Where grass growth is ahead of requirements, planned applications can be reduced or shelved altogether.

Conversely, the amount of N can be adjusted to stimulate growth when a shortfall in supply is indicated **(Section 4)**.

As a general rule, it is recommended that N is applied each time a field has been fully grazed to the post-graze point or cut for silage.

N should not be applied during a prolonged dry spell or in very wet weather.

Figure 11.2: Grass Growth Pattern and N Fertiliser Timings (300kg/ha)



Source: Milk from Grass, 2nd Edition, ed Thomas, Reeves and Fisher (The British Grassland Society).

Fertiliser Type

The most common sources of N are ammonium nitrate, calcium ammonium nitrate, urea and anhydrous ammonia.

The normal N contents of urea and ammonium nitrate (AN) are 46% and 34.5%, respectively. So the relative value of each product per kg of nitrogen can be calculated. Urea can often appear to be a cheaper source of N, but recent studies from ADAS, SAC and North Wyke show that N losses through volatilisation (loss to air) from urea applied over the season can be large (over 20%) compared with AN (less than 3%). At these kind of loss levels, AN will probably work out cheaper than urea and the N loss from urea is environmentally damaging.

N losses from urea are kept to a minimum when it is applied to moist neutral pH soils in spring and where there is light rain within 36 hours of application. So if confidence can be had in application timing and conditions, then urea can be effective; if not then AN is the safe option.

UK and European studies have, however, shown ammonium nitrate acid and calcium ammonium nitrate to be superior to urea in both grassland yields and losses to the environment.

In view of the sulphate deficiencies recognised in modern times and the importance of maintaining the correct nitrogen to sulphur ratio, ammonium sulphate and sulphur containing compounds may improve nitrogen utilisation efficiency.

NVZ Requirements

N fertilisation is controlled by law in designated Nitrate Vulnerable Zones.

The main things to note in NVZs for fertiliser applications are:

- Closed periods over winter for organic manures (1 September to 31 December for sandy or shallow soils, and 15 October to 15 January for all other soils)
- Closed period for inorganic fertiliser N applications from 15 September to 15 January
- From 1 January 2012 a maximum total annual nitrogen requirement of 300kg N/ha
- It is crucial to abide by the NVZ regulations and keep appropriate records. Further information is available from www.defra.gov.uk or from the Scottish and Welsh Offices, as appropriate.

Applying N to Grazed Grass/Clover Swards

Grass/clover swards produce a similar yield to grass-only swards with N applications of up to 200kg/ha, depending on clover content.

Little N application is generally required when there is a substantial quantity of clover present in the sward.

Some N may be required early in spring and/or early in autumn to encourage growth for early and late-season grazing respectively.

Under these circumstances the recommended applications are:

- 50kg/ha in mid-February to early-March
- 50kg/ha in late-August to early-September.

Modern varieties of clover can withstand normal applications of fertiliser N during the whole season, but they will not fix nitrogen if this approach is taken.

Applying N to Grass Silage Swards

N fertiliser applications for conservation depend on the type of silage to be made, the number of cuts, the SNS status of the soil and the Grass Growth Class of the site (**Table 11.8**).

Table 11.8 Total Annual N Requirement Recommendations for Grass Silage (kg/ha)

Milk Yield (litres/cow/year)	Concentrate use (tonnes/cow/year)	Stocking Rate (LU/ha)	Grass Growth Class	
			Very good/Good	Average
8,000 to 10,000	4.4	4.0	360	340
		3.5	310	300
		3.0	260	260
8,000 to 10,000	3.7	3.0	370	330
		2.6	310	300
		2.2	240	270
6,000 to 8,000	2.2	2.6	360	320
		2.2	280	290
		1.8	200	230
6,000 to 8,000	1.5	2.2	360	310
		1.8	260	260
		1.6	210	220
6,000 to 8,000	0.9	1.9	330	300
		1.7	280	250
		1.5	230	200
4,000 to 6,000	0.9	2.4	350	300
		2.1	280	260
		1.8	210	220
4,000 to 6,000	0.5	2.1	320	290
		1.9	270	250
		1.7	220	200
<5,000	0.5	2.5	350	340
		2.2	310	300
		2.0	270	270

The recommendations recognise that good grass growth sites produce more grass at the same fertiliser N input; thus, in some systems, growing grass on an average site takes more fertiliser N than on the same system on a good Grass Growth Class site.

Values in the above table are total annual requirement for moderate SNS. To obtain an applied inorganic fertiliser requirement, add 30kg N for low SNS situations, subtract 30kg N for high SNS situations and account for the contribution of clovers and organic manures.

Stocking rate is based on all dairy animals (in-milk cows, dry-cows and followers) where 1 cow = 1 LU.

To get an N requirement between stocking rates at the same milk yield/concentrate use combination, assume a proportional difference between the two values.

To get an N requirement between concentrate use at the same milk yield/stocking rate combination, add (subtract) 10kg N for every reduction (increase) of 0.1 tonnes concentrate/cow/year.

Split applications (approximately six over the season) to match the cutting pattern. For example, the recommended split of N application might be: for first cut – 40% (split further 15% Feb-Mar + 25% Apr; for second cut – 35% (could be split further 20% May + 15% Jun); for subsequent cuts – 25% (could be split further 15% Jul + 10% Aug).

In dry summers, if previous growth has been severely restricted then 3rd cut applications for moderate digestibility silage should be omitted.

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

To avoid nitrate accumulations in the forage which can make ensiling difficult, N applications should be neither excessive nor made at times when the sward is unable to fully utilise N – for example, during prolonged dry weather.

Nitrate concentrations in forage should ideally be less than 0.1% (1000 ppm).

At nitrate levels of 0.1- 0.25% fermentation is at risk.

Fermentation can be seriously affected with nitrate levels above 0.25%.

It is recommended that herbage samples are taken for analysis if there are any concerns about nitrate levels in swards.

Sufficient account must be taken of any N contribution from organic manures.

Applying N to Cutting and Grazing Swards

Following early spring grazing, the 1st cut application should be reduced by 25kg N/ha.

Where grazing follows one silage cut, obtain the two recommendations for the system (**Tables 11.6 and 11.8**), apply the 40% of the recommendation for 1st cut, then revert to 20% of the grazed grass total (starting May) and follow grazing, split accordingly.

Where grazing follows two silage cuts, obtain the two recommendations for the system (**Tables 11.6 and 11.8**), apply the 40% for 1st cut and 35% for 2nd cut, then revert to the 15% of the grazed grass total (starting July) and follow grazing, split accordingly.

Where grazing follows three silage cuts, obtain the two recommendations for the system (**Tables 11.6 and 11.8**), apply the 40% for 1st cut, 35% for 2nd cut and 25% for 3rd cut, then revert to the 10% of the grazed grass total (applied July) and follow grazing, split accordingly.

Applying N to Legume Swards for Cutting

Applications of N to grass/clover swards for silage-making are not generally recommended where the clover content needs to be maintained.

DairyCo research and other work from UK institutes suggests that some modern varieties of white clover are tolerant to inorganic fertiliser N applications, so that the cow nutrition advantages of a grass/white clover silage over a grass only silage can be obtained along with higher cut yields per hectare. However, where inorganic fertiliser N is applied, the atmospheric N fixed by the clover is reduced. Therefore, the advice is not to use inorganic fertiliser N when the objective is to rely on the white clover for inputs of N; where white clover is used only for cow nutritional benefits, then inorganic fertiliser N can be applied to boost herbage yield, but do not forget that this will be at the expense of the clover fixing N.

The above does not apply to grass/red clover silage swards. These should not receive any inorganic N inputs as this will reduce the proportion of red clover in the sward and defeat the object of using red clover.

Factsheet 12 provides guidance on interpreting forage analyses for better quality.

Assessing and Managing Sulphur Deficiency

Sulphur (S) is a major nutrient, used by plants and animals along with N in the formation of proteins. Therefore, S deficiency will markedly reduce the uptake and use of N in grass and grass/clover swards and leads to reduced levels of protein and sugars in herbage, as well as lower DM yields. Because of its metabolic use along with N, S is needed in proportion to the N used in a system and the likelihood of deficiency should be assessed regularly.

Sulphur deficiency is possible on all mineral soil types, and more likely to be severe on sandy and shallow soils.

The benefits of S fertilisation were identified in the 1980s with declining levels of deposition from industrial activity. Since then, the addition of sulphur to pasture – particularly after 1st cut silage – has become widespread. Atmospheric S deposition is now low across most of the UK.

Sulphur status is best assessed by analysis of herbage just before cutting.

The critical level is 0.25% total S or a N:S ratio not greater than 13:1.

The ideal N:S ratio for ruminant diets is around 10:1.

Where S deficiency is indicated, an application of 25-40kg S03/ha as a sulphate-containing fertiliser is recommended. Sulphur deficiency is mainly seen after first cut silage in cutting swards, but is now becoming more common during first cut growth and on grazing ground, particularly on lighter soils.

When pasture susceptible to deficiency is to be cut for silage, further applications are recommended after each cut.

Moderate applications of a sulphate-containing fertiliser like ammonium sulphate can be beneficial to grazing ground where S levels are deficient.

Maintain and Calibrate the Fertiliser Spreader

Experience from DairyCo Discussion Groups shows a substantial number of farmers are wasting money through badly-maintained and uncalibrated fertiliser spreaders. A spreader needs to be 20% out before you see striping in a grass field, but yield and grass quality losses will occur once spreading is out by more than 10%. In a dairy business, spending over £10,000 per year on inorganic fertilisers, quality and yield losses due to poor maintenance and calibration can result in £1000s being wasted. The spreader should be calibrated every year and for each product used; this only costs a few hundred pounds.

Factsheet 17, produced by the Agricultural Industries confederation (AIC), includes all the important points on choosing, maintaining, calibrating and using your fertiliser spreader.

Clover contributions

As a guideline, each 10% clover content will provide 50kg N/ha/year towards the 350kg generally considered necessary for a highly-productive sward.

Work at IBERS has shown that a grass/clover ley with 30% clover will produce up to 150kg N/ha a year. The clover plant really becomes active in summer. In the 120 days June to September period, this equates to 1.25kg N/ha/day. This is enough to keep summer grass growth going.

The target of around 30% clover in the sward (Section 10) will provide around half the annual N requirement.

A combination of grass and newer clover varieties has been shown to consistently outperform grass alone in three years of trials with N applications of 380kg/ha at IGER Trawsgoed:

- Increasing the efficiency of fertiliser N use by companion grass by 10% (**Table 11.8**)
- Improving the soil structure (as measured by its permeability to oxygen) by a factor of three, so reducing N losses and increasing fertiliser recovery
- Increasing the total N in the sward by around a third and the N content of companion grasses by 8%
- Stimulating more efficient soil nitrogen use.

Table 11.9: Fertiliser N Recovery in Grass and Grass/Clover Swards

% Fertiliser N Recovery (July-August 2002)			
Grass Component	Clover Component	Grass/Clover	Grass Alone
36.9	3.8	40.7	31.4

Source: DairyCo Report 00/T1/06, More Grass Less Fertiliser.

Growing clover with grass resulted in the grass taking up 10-19% more N than grass alone, offering the opportunity to reduce fertiliser bills by at least 10%.

Organic manures

An accurate assessment of the contribution made to N application by organic manures (**Table 11.10**) can significantly reduce the cost of purchased fertiliser.

Taking account of the nitrogen, phosphate and potash in organic manures can typically save £100–200/ha (Examples 11.1 and 11.2).

Table 11.10 Typical N Content and Availability in FYM and Slurries

Material	DM (%)	Nitrogen	% Total N Available to the Nest Crop Following Surface Applications					
			Autumn	Winter	Spring	Summer		
			S/S*	M/H*	S/S*	M/H*	All soils	All soils
Solid Manures								
FYM – fresh and old	25	6.0	5	10	10	10	10	10
Layer manure	35	19	15	30	25	25	35	35
Poultry litter	60	30	15	30	20	25	30	30
Slurries/Liquids**								
Cattle	2	1.6	10	35	30	30	50	40
	6	2.6	10	30	25	25	40	30
	10	3.6	10	25	20	20	30	25
Pig	4	3.6	15	40	35	35	55	55
Dirty water	0.5	0.5	15	40	35	35	50	30
Separated cattle Slurries (liquid portion)**								
Strainer box	1.5	1.5	Limited data. Assume same availabilities as for 2% DM cattle slurry					
Weeping wall	3.0	2.0						
Mechanical	4.0	3.0						

**S/S – sandy/shallow soils; M/H – medium/heavy soils*
***Table 11.11 gives rules of thumb for estimating slurry DMs*

Source: Defra Fertiliser Manual (8th Edition) – 2010, The Stationery Office, London.

A decision support system that can be used to accurately predict the fertiliser N value of organic manures on specific field basis has been launched by Defra.

MANNER has been developed using the latest results from research and is available free on a disk or CD-ROM from ADAS, at www.adas.co.uk/manner

Table 11.11: Rules of Thumb for Estimating Cattle Slurry DM

Type	Consistency	DM (%)
Undiluted slurry	Porridge	10
Slurry diluted with rainwater/washings	Thick soup	6
Separated slurry	Thin soup	4

Where applications of organic manures are made to pasture, grazing should be avoided for at least 21, preferably 28 days.

Silage should not be cut for a period of 6-8 weeks after the application of manure or dirty water as it may affect silage quality.

In the case of very solid manures a longer period may be required before silaging.

Where an early high-quality silage cut is to be taken it is advisable to delay manure applications until after silaging.

NVZ requirements mean that in England highly available N organic manures, such as slurry and poultry manure, cannot be applied to sandy or shallow soils between 1 September and 31 December, and between 15 October and 15 January for all other soils.

Planning Organic Manure Applications

Organic manure applications can best be planned and the financial benefits assessed using a simple set of calculations (**Examples 11.1 and 11.2**).

Example 11.1 Planning a Cattle Slurry Application for 2nd Cut Silage in a 6,000 to 8,000 litres/cow, 2.2 tonnes concentrate per cow, 2.2 LU/ha system with Grass Growth Class 'good', where soil P index = 2 and soil K index = 2-

	Nitrogen	Phosphate	Potash	Value * (£/ha)
1. Total nutrients in slurry (kg/m³) From analysis or tables 11.3 and 11.10	2.6	1.2	3.2	
2. Available nutrients in slurry (kg/m³) N from Table 11.10 or MANNER P&K from Table 11.3 (RB209)	0.78	0.6	2.9	
3. Nutrient requirements for 2nd cut silage (kg/ha) N from Table 11.8 (RB209) P&K from Table 11.2 (RB209)	98	25	90	162
4. Nutrients supplied by slurry (kg/ha) At a rate of 40 m³/ha (Row 2 x 40)	31.2	24	116	
5. Inorganic fertiliser required (kg/ha) (Row 3 – Row 4)	66.8	0	0	
6. Inorganic fertiliser supplied (kg/ha) 200kg/ha of 34.5% N	69	0	0	65
7. Saving in NPK fertiliser for 2nd cut (Row 3 value – Row 6 value)				97
8. Saving in NPK fertiliser for later cuts Allowing for surplus P&K supplied to 3rd cut				14
9. Total NPK saving (Row 7 value + Row 8 value)				111

**Assumes nitrogen @ £0.93/kg; phosphate @ £0.86/kg; potash @ £0.55/kg (costs as of March 2011)*

Worksheet 13 provides a pro forma for planning and valuing individual farm organic manure applications.

Example 11.2 Planning an Early Spring Cattle FYM Application in an 8,000 to 10,000 litres/cow, 3.7 tonnes concentrate per cow, 2.6 LU/ha system with Grass Growth Class 'average', where soil P index = 2 and soil K index = 2+

	Nitrogen	Phosphate	Potash	Value * (£/ha)
1. Total nutrients in FYM (kg/t) From analysis or tables 11.3 and 11.10	6.0	3.2	8.0	
2. Available nutrients in FYM (kg/t) N from Table 11.10 or MANNER P&K from Table 11.3 (RB209)	0.6	1.9	7.2	
3. Nutrient requirements for 1st cut silage (kg/ha) N from Table 11.8 (RB209) P&K from Table 11.2 (RB209)	120	40	60	179
4. Nutrients supplied by slurry (kg/ha) At a rate of 30 tonnes/ha (Row 2 x 30)	18	57	216	
5. Inorganic fertiliser required (kg/ha) (Row 3 – Row 4)	102	0	0	
6. Inorganic fertiliser supplied (kg/ha) 300kg/ha of 34.5% N	104 82	0	0	97
7. Saving in NPK fertiliser for 1st cut (Row 3 value – Row 6 value)				82
8. Saving in NPK fertiliser for later cuts Allowing for surplus P&K supplied to 3rd cut				100
9. Total NPK saving (Row 7 value + Row 8 value)				182

**Assumes nitrogen @ £0.93/kg; phosphate @ £0.86/kg; potash @ £0.55/kg (costs as of March 2011)*

Worksheet 13 provides a pro forma for planning and valuing individual farm organic manure applications.

Spreading Organic Manures

Slit aeration of established grassland in early spring, prior to slurry application, can enhance aerobic microbial activity resulting in improved organic manure utilisation.

To maximise the contribution of the nutrients in farm slurries and manures it is important to calibrate machinery carefully and operate it to give accurate applications.

Organic manures should be:

- Spread evenly and at known rates
- Incorporated rapidly wherever possible or applied with a technique that will minimise ammonia losses (for example band spreading or shallow injection)
- Applied in spring, where possible, to reduce nitrate leaching.

Application rates need to be controlled to avoid:

- Smothering, scorching and poor silage quality
- Surface run-off
- Exceeding plant requirements.

The Code of Good Agricultural Practice for the Protection of Water recommends applications of slurry should not be in excess of 50m^3/ha (**Figure 11.3**).

At this level of application the risk of adverse effects on the crop are minimal. Higher levels can cause problems (**Figure 11.4**).

Figure 11.3: Cattle Slurry Applied at 50m^3/ha

Source: Creedy Associates

Figure 11.4: Cattle Slurry Applied at 100m^3/ha

Source: Creedy Associates

Consult NVZ regulations for legal limits of slurry and FYM applications and closed periods for spreading.

The maximum recommended application of farmyard manure is also 50 tonnes/ha (**Figure 11.5**).

Figure 11.5: Farmyard Manure Applied at 50 tonnes/ha

Source: Creedy Associates

Spreading manures on grazing pastures presents a disease transfer risk, most notably from untreated slurry.

The disease risk is minimised by leaving the pastures as long as possible before grazing.

Aerobic composting of solid manures will significantly reduce the disease risk.

Manures are best stored for at least one month prior to spreading.

Pastures should not be grazed for at least one month and preferably eight weeks after spreading and until visible signs of solids have disappeared.

The use of organic manures is controlled in NVZs.

In England this currently means:

- High available N manures cannot be applied to grassland on sandy and shallow grassland soils between 1 September and 31 December
- On all other soils, high available N manures cannot be applied between 15 October and 15 January
- If the whole farm is within an NVZ, application is limited to 170kg N/ha, including grazing deposition. A derrogation to 250kg N/ha can be applied for
- The overall field limit excluding grazing deposition is 250kg N/ha.

Nitrogen balances

Planning N inputs and offtake on a field-by-field basis helps to identify where manure N can be used to best effect (**Example 11.3**).

Example 11.3a: Assessing N Inputs

		Legumes	Organic manures				Grazing	Fertiliser	Total Input	
Field name or number	Size (ha)	N input* (kg/ha)	N Content** (%N x % availability)	Applications (m^3/ha or tonnes/ha) 1st	2nd	N input (kg/ha)	N input*** (kg/ha)	Total N applied (kg/ha)	N per Hectare (Kg N/ha)	Overall N (kg/ ha)
	A	B	C	D1	D2	E = C x (D1+D2)	F	G	H = B+E+F+G	I = H x A
Field 1	2.8	100	1.04	50	20	72.8	80	70	322.8	902.8
Field 2										
etc										
Farm Total										

**Assumed to be 100kg/ha from 10% clover content in the sward.*
***2.6% N content for 6% cattle slurry at 40% availability for spring applications (Table 11.10) – 2.6 x 0.4 = 1.04*
****Section 13: Example 13.1, assuming 550kg cows grazing for a third of the year at 2.5 cows/ha – (96 ÷ 3) x 2.5 = 80*

Example 11.3b: Assessing N Offtake

		Silage						Grazing					Total Offtake	
		1st Cut			2nd Cut									
Field Name or Number	Size (ha)	Yield (kg DM/ ha)	N Content* (%)	N Offtake (kg/ha)	Yield (kg DM/ha)	N Content* (%)	N Offtake (kg/ha)	Daily Yield ** (kg DM/ha)	Days	Yield in season (kg DM/ ha)	N Content* (%)	N Offtake (kg/ha)	N per Hectare (kg N/ha)	Overall N (kg)
	A	B	C	D = B x C	E	F	G = E x F	H	I	J = H x I	K	L = K x J	M = D +G + L	N = A x M
Field 1	2.8	3500	3.0	105	2500	2.5	62.5	50	120	6000	2.7	162	329.5	922.6
Field 2														
etc														
Farm Total														

** N content = Protein content in DM from analysis ÷ 6.25*
*** Average sward growth (Section 4; Example 4.3)*

Worksheet 14 provides a pro forma for calculating individual farm N balances.

D.

Example 11.3c Assessing N Balance

Field Name or Number	Size (ha)	Total N Input (kg/ha)	Total N Offtake (kg/ha)	N Surplus or Deficit	
				(kg/ha)	(kg/field)
	A	B = Column H (3a)	C = Column M (3b)	D = B – C	E = D x A
Field 1	2.8	322.6	329.5	+6.9	+19.3
Field 2					
etc					
Farm Total					

Summary

- Most swards should be maintained with a pH in the range 6.0-6.5 and limed whenever values fall below 6.0
- Good P and K fertilisation is essential to sward productivity, especially where silage cuts remove large amounts of the nutrients
- The soil nitrogen supply (SNS) status of fields should be assessed regularly
- Maximum recommended N application rates should not be exceeded
- N applications should be used to manipulate sward growth each time a field has been fully grazed to the post-graze point or cut for silage
- Grass/clover swards produce at similar levels to grass-only swards with an N application of up to 200kg/ha, depending on clover content
- 20-30kg DM can be produced for each kg N applied up to 300kg N/ha/year
- The sulphur content of herbage should be 0.25% or the N:S ratio not greater than 13:1
- Taking accurate account of the N, P and K in organic manures can save £100–200/ha in inorganic fertiliser applications.

Clover in the sward improves:

- Companion grass fertiliser N utilisation efficiency by 10%
- Soil structure, leading to reduced N loss and better fertiliser recovery
- Overall sward N content by about one third.

See also...

Section 4:	Planning Your Grazing
Section 9:	Managing Your Silage-making
Section 10:	Maximising Sward Productivity
Section 15:	Factsheet 12: Herbage Analysis
Section 16:	Worksheet 13: Organic Manure Contribution Worksheet 14: Balancing N Inputs and Offtake