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Making better use of livestock manures on grassland

Booklet 2

Booklet 1 Making better use of livestock manures on arable land

Booklet 2 Making better use of livestock manures on grassland

Booklet 3 Spreading systems for slurries and solid manures

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NEW RECOMMENDATIONS

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Slurries and solid manures are valuable fertilisers but may also be potential sources of pollution. With increasing economic and environmental pressures on farm businesses, it makes sense to exploit the fertiliser value of manures, while taking action to prevent pollution.

The booklets in this series will assist in achieving these aims by providing practical advice so that you can:

- save on the cost of inorganic fertiliser
- operate machinery effectively
- minimise management problems
- comply with the MAFF Codes of Good Agricultural Practice.

The booklets have been produced jointly by IGER, ADAS and SRI and are available free of charge. The information they contain is based largely on research conducted by these three organisations over the past ten years, much of which was paid for by MAFF.

This booklet explains how to:

- use manures on the farm for grass and forage crop production
- avoid sward contamination and problems with silage quality
- calculate manure application rates
- make savings on fertiliser use.

Booklet 2

Handling of slurries and solid manures creates certain safety hazards for both operators and the public. You must comply with relevant legislation. Key sources of information are listed on page 20.

In this booklet, **manures** refer to organic materials which supply organic matter to the soil, together with plant nutrients (in relatively small concentrations compared to inorganic fertilisers). They may be either **slurries** or **solid manures**.

Slurries consist of excreta produced by livestock whilst in a yard or building mixed with rainwater and wash water and, in some cases, waste bedding and feed. Slurries can be pumped or discharged by gravity.

Solid manures include farmyard manure (FYM) and comprise material from covered straw yards, excreta with a lot of straw in it, or solids from mechanical slurry separators. Most poultry systems produce solid manure. Solid manures can generally be stacked.

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Benefits of better manure use on grassland farms

Most of the nitrogen (N), phosphorus (P) and potassium (K) in livestock diets is excreted in dung and urine. Manures contain useful amounts of these plant available nutrients, as well as the other major nutrients sulphur (S) and magnesium (Mg), and trace elements.

Based on recent prices for N, P and K fertilisers, the slurry produced by 100 dairy cows over the winter housing period has a potential value of almost £2000. With opportunity to apply to grassland on several occasions during the growing season, this could provide up to 20%, 100% and 80%, respectively, of the N, P and K fertiliser required by grassland used for hay or silage production. Bearing in mind the overall costs of manure management, it is well worthwhile taking a little extra trouble to achieve these savings and at the same time reduce pollution risks. Experience confirms that commercial dairy farms can achieve such savings.

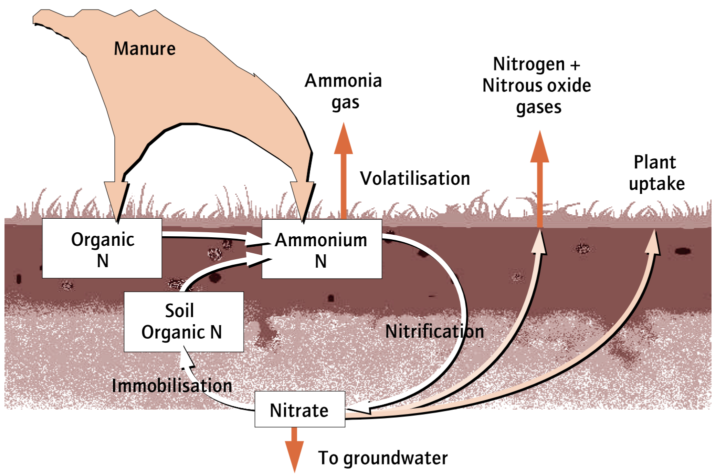
Understanding nutrient losses

Two types of pollution can arise from manures, both of which result in nutrient losses:

1 **'Point source' water pollution** can occur through direct contamination of a watercourse from a burst or overflowing slurry store, or from yard runoff during heavy rain. Such incidents can have catastrophic effects on fish and other aquatic life, mainly because of the high biochemical oxygen demand (BOD) and dissolved ammonia contained in manures. BOD is a measure of the amount of oxygen consumed by micro-organisms in breaking down organic matter and typically ranges between 10,000 to 30,000 mg/l (parts per million) for slurries compared with 300-400 mg/l for raw domestic sewage.

2 **'Diffuse' pollution** can affect water and air and, unlike point source pollution, is not easily seen. The resulting nutrient losses are associated with farming practices over a wide area and extended time, rather than with a particular action or event and may have important long-term effects on the environment.

Figure 1 Nitrogen cycle, showing main transformations and losses



Nitrogen (N) is readily lost from manures either dissolved in water or as a gas. Nitrogen is present in manures both in mineral and organic forms. The mineral N is present as ammonium-N (the same as in 'bag' fertilisers) and can be lost to the atmosphere as ammonia gas. Following conversion in the soil of ammonium- to nitrate-N, further losses may also occur through nitrate leaching and denitrification, that is gaseous loss as nitrous oxide and nitrogen. (See **Figure 1**.) Each of these losses can have undesirable effects on the environment, as outlined below, and represent an economic loss to the farmer.

- *Ammonia gas* (NH_3) can be released rapidly into the atmosphere from manures spread on the land, as well as from stores and livestock buildings, and may then be deposited either nearby or after being transported over long distances in the atmosphere. Ammonia deposition can contribute significantly to soil acidification, which is of particular concern in some woodland soils. It can also raise N levels in nutrient poor soils, such as botanically-rich habitats, for example old meadows and heathlands, so changing the types of plants that grow there. Deposited ammonia can contribute to nitrate leaching losses.
- *Nitrate* (NO_3) losses from agricultural land have meant that some ground waters, especially in eastern and central England, which could otherwise

supply high quality water, are no longer usable or require expensive treatment before use. Increasing nitrate levels in drinking water have resulted in the designation of Nitrate Vulnerable Zones (NVZs) under the EU Nitrate Directive. These NVZs are where nitrate concentrations in water are close to or exceed the permitted legal limit of 50 mg/l NO_3 (parts per million). NVZ regulations aim to control nitrate concentrations in ground and surface waters by careful management of land, inorganic fertiliser N and organic manure applications.

- *Nitrous oxide* (N_2O) is one of the gases responsible for the 'greenhouse effect'. Both N_2O and nitrogen gas (N_2), which is harmless to the environment, can be produced from the microbiological breakdown of nitrate in the soil, whether derived from manures or fertilisers. The presence of manures encourages this process.
- *Phosphorus*, unlike nitrate, is normally held firmly in the soil, but excessive applications of manures can result in soil P enrichment and eventual loss through runoff, erosion or leaching to water. This can cause excessive growth of aquatic plant life and algal blooms.
- *Potassium* can also be lost by leaching and in surface runoff. This means a decrease in the fertiliser value of manures but is not a risk to the environment.

Manure production

The volume of manure produced can vary considerably between two livestock units of similar size, but can be estimated using guideline quantities of excreta produced by stock as shown in **Appendix A**, on-farm estimates of bedding use, washwater volumes, yard areas (contributing drainage to the slurry system) and local rainfall data.

In practice, a roughly equal volume of water and excreta goes into store, i.e. a doubling of the excreta volume, resulting in a slurry dry matter (DM) content of 5–6% on dairy farms. Even greater dilution may occur on pig farms. The moisture content and analysis of solid manures will be affected by rainfall and the degree of 'composting' that occurs, which can reduce both the weight and volume of manure produced.

Nutrient content of manures

For reliable fertiliser planning, it is important to know the nutrient content of applied manures. Nutrient content is given as the element for nitrogen (N) and as the oxide for phosphate (P_2O_5), potash (K_2O), sulphur (SO_3) and magnesium (MgO), because this is the convention for expressing their content in fertilisers. It is far better to measure or estimate the nutrient content, rather than rely on 'experience' or guesswork. You can:

- *refer to 'standard values'* – which are useful for general planning purposes and are based on the analysis of large numbers of samples. (See **Table 1**.)
- *sample manures for analysis* – as the nutrient content of manures can be variable, sampling and analysis of manures will provide the most reliable information. It is important that sampling is carried out carefully, involving the collection of multiple samples from which to take the final sample for analysis. Guidance on obtaining representative manure samples for analysis is provided in Booklet 3, *Spreading systems for slurries and solid manures*.

  The *laboratory analyses* should include: dry matter (DM), total N, P, K, S and Mg, and ammonium-N (readily crop available N). Additionally, for well composted FYM nitrate-N should be measured and for poultry manures uric acid-N.
- For slurries, laboratory results can be supplemented by *on-farm* 'rapid' N meter measurements of ammonium-N. A slurry hydrometer can also be used to estimate DM, total N and P contents. Equipment suppliers are listed in **Appendix B**.

Table 1 Typical nutrient content of livestock manures (fresh weight basis)

Manure Type	Dry matter (%)	Total nutrients: Nitrogen (N)	Total nutrients: Phosphate (P_2O_5)	Total nutrients: Potash (K_2O)	Available nutrients (2): Nitrogen (N)	Available nutrients (2): Phosphate (P_2O_5)	Available nutrients (2): Potash (K_2O)
Solid manures			kg/t			% of total nutrients	
Cattle FYM (1)	25	6.0	3.5	8.0	See Table 2	60	90
Pig FYM (1)	25	7.0	7.0	5.0		60	90
Sheep FYM (1)	25	6.0	2.0	3.0		60	90
Duck manure (1)	25	6.5	5.5	7.5		60	90
Layer manure	30	16	13	9	See Table 2	60	90
Broiler/turkey litter	60	30	25	18		60	90
Slurries/liquids			kg/m^3			% of total nutrients	
Dairy	2	1.5	0.6	2.0	See Table 2	50	90
	6	3.0	1.2	3.5			
	10	4.0	2.0	5.0			
Beef	2	1.0	0.6	1.5	See Table 2	50	90
	6	2.3	1.2	2.7			
	10	3.5	2.0	3.8			
Pig	2	3.0	1.0	2.0	See Table 2	50	90
	4	4.0	2.0	2.5			
	6	5.0	3.0	3.0			
Dirty water	<1	0.3	Trace	0.3	See Table 2	50	100
Separated cattle slurries (liquid portion)			kg/m^3			% of total nutrients	
Strainer box	1.5	1.5	0.3	2.2	See Table 2	50	90
Weeping wall	3.0	2.0	0.5	3.0		50	90
Mechanical separator	4.0	3.0	1.2	3.5		50	90

Notes

1) Values of N and K_2O will be lower for FYM stored for long periods in the open.

2) Nutrients available for utilisation by the next crop.

To convert kg/t to kg/tonne, multiply by 2.

To convert kg/m^3 to units/1000 gallons, multiply by 9.

Nutrient (N, P, K) availability

Chemical analysis gives the total nutrient content of manures but the effectiveness or 'availability' of nutrients in terms of short-term crop response, i.e. next crop to be grown, is usually lower. For phosphate and potash, some information is summarised in **Table 1**.

The ammonium-N content of manures provides a good indication of readily available N supply. For poultry manures, readily available N is a combination of ammonium-N and uric acid-N (UAN). In all cases, availability will be affected by N losses following manure application to land, mostly as ammonia gas or nitrate leaching. The available N supplied by manures is affected by manure type, slurry dry matter (DM) content, application time and soil type (see **Table 2**). Slurry thickness, i.e. DM content, has two important effects:

- Nutrient content increases with increasing DM.
- Slurry N availability decreases with increasing DM – less ammonia is lost from dilute slurries.

The data given in **Tables 1** and **2** provide general guidance on the nutrient value of manures. **Table 2** summarises N availability for pig and cattle slurries at three different DM levels. It also takes into account the effect of application timing on nitrate leaching losses, which are greatest following the autumn application of manures containing a high proportion of readily available N.

More detailed field-specific guidance on the crop availability of manure N is provided by the ADAS 'MANNER' computer program (see **Figure 2**), which is available free of charge from ADAS (See 'How to obtain more information' on page 20).

Figure 2 ADAS MANNER – **MAN**ure **N**itrogen **E**valuation **R**outine

Table 2 Percentage of total nitrogen available to the next crop following **surface application** of livestock manures (% of total N)

Soil type/ manure type	Dry matter (%)	Timing: Autumn (Aug–Oct) [1]		Winter (Nov–Jan) [1]		Spring (Feb–Apr)	Summer (May–July)
		Sandy/ shallow[2]	Medium/ heavy[2]	Sandy/ shallow[2]	Medium/ heavy[2]	All soils	All soils
Fresh FYM [3]	25	5	10	10	15	20	ND [4]
Old FYM [3]	25	5	10	10	10	15	ND [4]
Layer manure	30	10	20	15	30	35	ND [4]
Broiler/turkey litter	60	10	20	15	25	30	ND [4]
Cattle slurry [5]	2	5	20	25	40	50	35
	6	*5*	*15*	*20*	*30*	*35*	*20*
	10	5	10	10	15	20	10
Pig slurry [5]	2	5	25	30	50	60	40
	4	*5*	*20*	*25*	*40*	*50*	*30*
	6	5	15	20	30	40	25
Dirty water	<1	0	40	10	60	80	50

Notes

1) Assuming 350 mm of rainfall (after autumn application) and 200 mm (after winter application) up to the end of soil drainage (usually end March). For spring or summer applications, rainfall is not likely to cause movement of nitrogen to below crop rooting depth.
2) Sandy/shallow – means light sand and shallow soils.
Medium/heavy – means medium, deep fertile silt and deep clay soils.
3) Fresh FYM has not been stored prior to land application (estimated ammonium N content 25% of total N).
Old FYM has been stored for 3 months or more (estimated ammonium N content 10% of total N).
4) ND – No Data.
5) For separated cattle and pig slurries, use the 2% dry matter values.

Example 50 m^3/ha of 6% DM cattle slurry, containing 3.0 kg/m^3 total N, applied in January to a medium textured grassland soil, will provide 45 kg/ha N towards the spring fertiliser N requirement (i.e. 30% of 150 kg/ha total N).

Sulphur and magnesium content

Manures contain useful quantities of sulphur (S) and magnesium (Mg). (See **Table 3**.) Sulphur is required by crops in similar amounts to P. With inputs from the atmosphere continuing to decline due to reducing levels of airborne pollution (sulphur dioxide), crop responses to added S are increasingly common. Grass for silage is particularly responsive.

Table 3 Typical sulphur and magnesium content of livestock manures

Manure type	DM %	Total S as SO_3 kg/t or kg/m^3	Total Mg as MgO kg/t or kg/m^3
Cattle FYM	25	1.8	0.7
Pig FYM	25	1.8	0.7
Poultry layer manure	30	3.8	2.2
Broiler litter	60	8.3	4.2
Cattle slurry	2	0.4	0.4
	6	0.8	0.7
	10	1.1	1.0
Pig slurry	2	0.5	0.3
	4	0.7	0.4
	6	0.9	0.5

About 50% of the S in cattle slurry is available for crop uptake. However, some leaching of S can occur during the winter months, so it is best not to rely totally on S from autumn applications of slurry. Crop responses to sulphur are particularly common on freely drained soils following wet winters. Magnesium inputs from manures should largely be regarded as contributing to the maintenance of soil reserves.

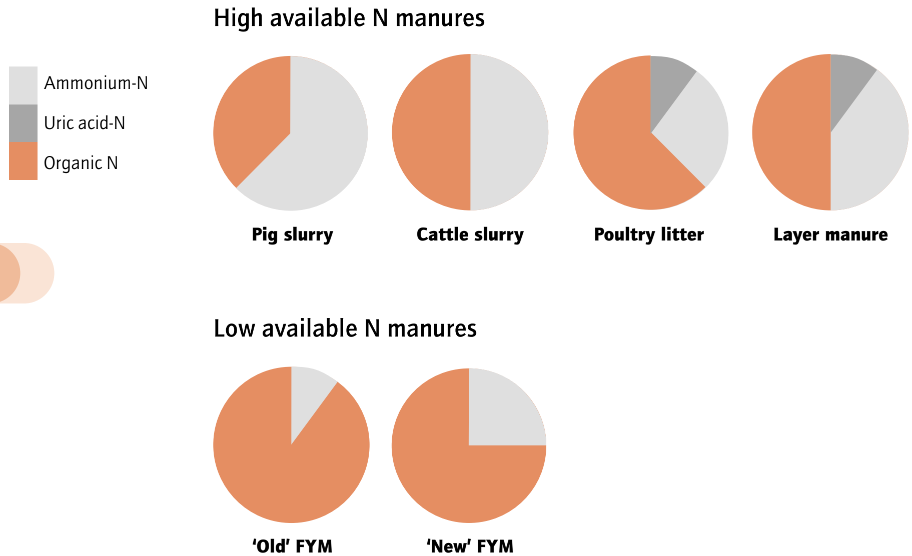
Example An application of 50 m^3/ha cattle slurry would supply around 40 kg/ha SO_3 and 35 kg/ha MgO; with about 20 kg/ha SO_3 available (50%), this application would usually supply sufficient sulphur for one cut of silage.

Application timing

To make best use of N in organic manures, they should be applied as close as possible to the time when the crop is actively growing and N demand is greatest – generally during the late winter/early spring period.

The N value of manures will usually be considerably reduced if applied in autumn or early winter because more N will be lost, mostly by leaching. This is particularly true for manures with a high readily available N content, i.e. slurries or poultry manures. (See **Figure 3**.)

Figure 3 Typical readily available N content of farm manures



Remember that:

- Applications in March are best for efficient use of slurry and poultry manure N. Applications in the autumn or early winter will be subject to significant leaching losses; efficiency of summer applications is likely to be reduced by increasing ammonia losses.
- There are opportunities for the application of slurry and poultry manure in late winter and early spring on well drained grassland and before spring-sown forage crops.
- FYM can be applied at any time, subject to soil conditions and crop growth.
- The slight risk of scorch or smothering of the sward, or adverse effects on silage quality following manure applications in late March, can be minimised by controlling the application rate. See below.

Limits on application rate

There are three main reasons why manure application rates need to be controlled:

1 Smothering/scorch and poor silage quality – slurry DM loading is critical for surface applications. If more than 4 t/ha of slurry DM are applied, some reduction in grass DM yield can be expected. This means that application rate should not exceed 65 m^3/ha for a typical cattle slurry with 5–6% DM content. The example below shows that sensible rates of slurry application are unlikely to have adverse effects.

2 Surface runoff – the MAFF Water Code advises that slurry applications should not generally exceed 50 m^3/ha, to minimise the risk of nutrient losses via surface runoff. Runoff risk is closely linked with slurry DM loading and with high rainfall events within three to four days of application to land.

3 Crop nutrient requirement – target application rates should always relate to the nutrient requirement of the next crop while avoiding significant excesses of nutrients, particularly of N or K. Detailed examples of good practice are shown in the later section on 'Use in practice and financial benefits'.

Example	40 m^3/ha of 6% DM cattle slurry, applied in March, will supply 120 kg/ha total N and about 40 kg/ha of crop available N (**Tables 1** and **2**), 50 kg/ha P_2O_5 (25 kg/ha available) and 140 kg/ha K_2O (125 kg/ha available). This represents useful, not excessive, nutrient supply and, with a solids loading of 2.4 t/ha, is unlikely to cause any increase in nutrient loss by runoff or suppression in grass growth.

Odour nuisance

Complaints are commonly received about unpleasant smells from farms, especially as a result of manure spreading:

- Avoid spreading in the evening or at weekends, when people are more likely to be at home, and pay attention to wind direction in relation to neighbouring houses.
- Try to restrict spreading to when weather conditions cause smells to be dispersed rapidly e.g. sunny, windy days followed by cloudy, windy nights.
- Using an injector or band spreader is an effective means of reducing smells.
- Do not spread slurries at rates in excess of 50 m^3/ha.

For more detailed advice, see the MAFF Air Code and Booklet 3 of this series.

Use of manures on grassland and forage crops

Grass for silage production

Silage grass requires much more potash than phosphate. Cattle slurry, which contains large amounts of K relative to crop available N and P, is ideally suited to this situation. Slurry N will be less efficiently used in summer following silage cuts because ammonia losses are higher on dry soils. Apply slurry in February and March, where possible.

Poultry manure and FYM application rates should be carefully controlled to avoid the risk of sward damage and of solids contaminating grass cuts, thereby affecting silage quality. Rates should be based on nutrient supply; avoid applications during the summer period.

To encourage a low pH and good fermentation conditions, grass cuts following solid manure applications and late slurry applications should be wilted before ensiling or an effective silage additive used.

Forage crops

Forage crops, particularly forage maize, provide an opportunity to apply manures prior to drilling in late spring but they must not be regarded as a convenient 'dumping ground' for large amounts of slurry and FYM. Although maize can apparently tolerate heavy applications of manures, without adverse effects on the crop, nutrient losses via surface runoff and leaching are likely to occur.

For forage crops, as with other crops, manures should be applied with the aim of balancing nutrient supply and demand, topping up with inorganic fertiliser as necessary. See **Example 3** on page 19. Manures should be incorporated into the soil as soon as possible after spreading, preferably within 6 hours for slurries and 24 hours for solid manures, to minimise ammonia losses.

Grass for grazing

Using manures on grazing land can lead to significant problems. Avoid doing this where possible.

- **Disease**. Spreading manures onto pasture can play a role in transferring disease to healthy stock. The main risk is from spreading fresh, unstored slurry. Risks are reduced by storage, using low application rates and leaving the pasture for as long as possible before grazing.

  Aerobic composting of solid manures by turning of manure heaps or forced aeration, will significantly reduce the risk of disease transmission. Store slurries and solid manures for at least one month before spreading. Pasture should not be grazed for one month, or preferably eight weeks afterwards, or until all visible signs of the slurry solids have disappeared, to minimise

the risk of transferring disease. Six months should elapse before grazing young stock more susceptible to infection.

- **Reduced herbage intakes.** If they have no choice, cattle may graze from swards contaminated with slurry, but herbage intakes may fall with a corresponding reduction in milk yields and changes in milk composition. This is a particular risk when thick slurries (>8% DM) are applied in dry weather. Apply dilute slurries, restrict application rates to 25 m^3/ha or less and, where possible, leave eight weeks or more before grazing starts.
- **Nutrient imbalance in herbage**. Large or repeated manure applications can result in the build up of K in the soil, which can reduce Mg uptake by the herbage, increasing the risk of grass staggers (hypomagnesaemia) in stock. This applies particularly to cattle slurry because it contains large amounts of K relative to N and P. Grazing cattle and ewes are most at risk early in the spring, when even a single application of cattle slurry may result in rapid K uptake and reduced herbage Mg. Herbage analysis can be used to provide further guidance, but slurry applications to grazing land in late winter/early spring are best avoided. If soil or herbage analysis indicates potash is required for grazed swards, this is best applied either as fertiliser or slurry during mid-season, i.e. not before May.

Heavy metals

Pig and poultry feed is frequently supplemented with zinc and/or copper. The application of manures to land may, in the long term, cause a build-up of these metals in the soil. The greatest risk to livestock is from eating herbage coated with slurry. Sheep are particularly susceptible to copper poisoning and should not be grazed until there are no visible signs of slurry contamination on grass herbage. Application using an injector or trailing shoe applicator is an effective way of reducing the risk from pig slurry.

Application methods

The relative performance of the main spreader types is described in Booklet 3, *Spreading systems for slurries and solid manures.*

Application equipment, when set up and operated correctly, can give good results on grass. Knowing the rate of manure applied and how to keep it within sensible target levels is particularly important. The new slurry application techniques, including trailing hoses, trailing shoes and shallow injection, with rotary distribution of slurry to each outlet, give more precision than the normal surface spreaders and provide other benefits including:

- reduced ammonia (30 – 70% compared with broadcasting) and odour emission
- more consistent results from slurry N
- reduced herbage contamination.

Planning the use of manures and fertilisers

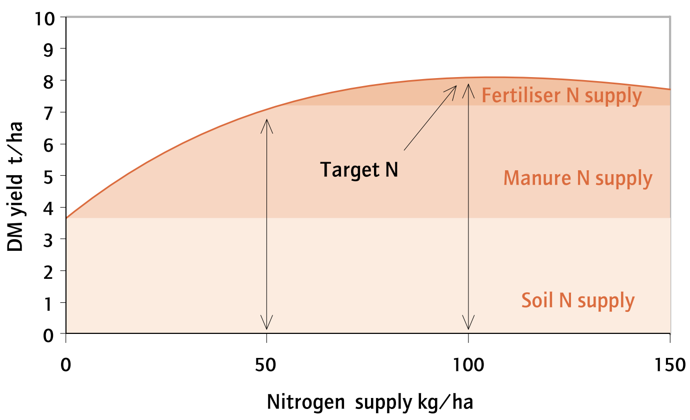
Nitrogen is usually the first consideration in the fertiliser plan. Phosphate and potash are easier to manage, particularly where soil P and K status is at ADAS Index 2/3 and these nutrients are required largely for maintenance of soil reserves. When fertiliser and manure nutrients are used together, they are largely additive both in terms of crop response and their effects on soil nutrient status.

A typical N response curve for first-cut silage DM yield, shows that a significant proportion of yield is obtained from soil N reserves. (See **Figure 4**.) The grass continues to respond to extra N up to the optimum of about 100 kg/ha N. If half of this is supplied from manure, in one or more dressings, with the other half from inorganic fertiliser, i.e. 50 kg/ha N, the majority of the yield response can be 'guaranteed' from these sources.

Variation in the manure N supply will have little effect on the resulting yield at the target level of 100 kg/ha crop available N. Where the response curve is almost level, i.e. a few kg extra or less, N will have little effect on yield.

To minimise the impact of variable manure N supply, you should aim to supply no more than 50–60% of the crop N requirement from manures. This is better than using only mineral fertilisers, because it will give significant financial savings and impose no risk of incurring any yield deficit.

Figure 4 Supplying first-cut silage N requirement from fertiliser and manure sources



Only 'maintenance' applications are needed for phosphate at soil P Index 2, and for potash at soil K Index 2. Grass yield response to applied P and K will generally occur only at Indices 0 and 1. Maintenance P and K, which can be supplied by manures or fertilisers, are calculated to balance the nutrient removed in average crops, thus maintaining satisfactory soil reserves.

Use in practice and financial benefits

The following worked examples will help to demonstrate the principles involved and the potential for savings. In the examples, it is assumed that the fields are on medium soils with soil P at Index 2 and K at Index 1, following recent analysis. The manures have not been analysed, so planning is based on the typical nutrient content data in **Tables 1** and **2**.

Example 1 Layer manure applied in early spring before first-cut silage saves up to £92/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Value [4] (£/ha)
1 Estimate total nutrients in manure (kg/t)				
Analysis of representative sample or reference to values in Table 1	16.0	13.0	9.0	
2 Estimate available nutrients in manure (kg/t)				
Reference to Table 1 for P and K		7.8	8.1	
Reference to Table 2 for N (or MANNER)	5.6 [1]			
3 Requirement for 1st cut silage (kg/ha)				
MAFF Fertiliser Recommendations book – RB 209 or other recognised system	120	40M [2]	110	**70**
4 Calculate manure supply of nutrients (kg/ha)				
Application rate to supply 50–60% of crop N requirement (12.5 t/ha manure will supply 70 kg/ha N)	70	160M [3]	100	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – stage 4	50	0	10	
Above could be supplied by 200 kg/ha of 25:0:16	50	0	32	**21**
6 Saving in NPK fertiliser inputs, *1st cut*				
Stage 3 costs – stage 5 costs				**49**
7 Saving in PK fertiliser inputs, *later cuts*				
Allowing for surplus P & K supplied to 1st cut				**43**

Notes

1) Poultry layer manure applied in early spring; N availability 35% of total N (Table 2) .
2) With soil P Index 2, P_2O_5 requirement for maintenance (M) of soil reserves.
3) Where P_2O_5 requirement is for maintenance, total P_2O_5 content of manure used in calculations.
4) Assuming : N= 30 p/kg; P_2O_5= 30 p/kg ; K_2O= 20 p/kg (based on recent inorganic fertiliser prices).

Example 2 Cattle slurry applied after first-cut silage saves up to £52/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Value (4) (£/ha)
1 Estimate total nutrients in slurry (kg/m³)				
Analysis of representative sample or reference to values in Table 1	3.0	1.2	3.5	
2 Estimate available nutrients in slurry (kg/m³)				
Reference to Table 1, for P and K		0.6	3.2	
Reference to Table 2, for N (or MANNER)	0.6 (1)			
3 Requirement for 2nd cut silage (kg/ha)				
MAFF Fertiliser Recommendations book – RB 209 or other recognised system	100	25M (2)	100	**58**
4 Calculate slurry supply of nutrients (kg/ha)				
Application rate based on nutrient requirements and supply in slurry (application rate 40 m³/ha will supply sufficient P and K and some N)	24	48M (3)	125	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – stage 4	75	0	0	
Above could be supplied by 200 kg/ha of 34.5% N	70	0	0	**21**
6 Saving in NPK fertiliser inputs, *2nd cut*				
Stage 3 costs – stage 5 costs				**37**
7 Saving in PK fertiliser inputs, *later cuts*				
Allowing for surplus P and K supplied to 2nd cut				**15**

Notes

1) Slurry with 6% DM content, applied in summer, N availability 20% of total N (Table 2).
2) With soil P Index 2, P_2O_5 requirement for maintenance (M) of soil reserves.
3) Where P_2O_5 requirement is for maintenance, total P_2O_5 content of manure used in calculations.
4) Assuming : N = 30 p/kg; P_2O_5 = 30 p/kg ; K_2O = 20 p/kg (based on recent inorganic fertiliser prices).

Example 3 Cattle FYM applied in April before forage maize saves £92/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Value (5) (£/ha)
1 Estimate total nutrients in FYM (kg/t)				
Analysis of representative sample or reference to values in Table 1	6.0	3.5	8.0	
2 Estimate available nutrients in FYM (kg/t)				
Reference to Table 1, for P and K		2.1	7.2 (1)	
Reference to Table 2, for N (or MANNER)	1.2 (1)			
3 Requirement for forage maize (kg/ha)				
MAFF Fertiliser Recommendations book – RB 209 or other recognised system	80	60M (2)	205	**83**
4 Calculate manure supply of nutrients (kg/ha)				
Application rate to supply approx. 50% of crop N requirement (30 t/ha FYM will supply 35 kg/ha N)	35	105M (3)	215	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – stage 4	45 (4)	0	0	
Above could be supplied by 150 kg/ha of 34% N	51 (4)	0	0	**15**
6 Saving in NPK fertiliser inputs, *maize*				
Stage 3 costs – stage 5 costs				**68**
7 Saving in PK fertiliser inputs, *later crops*				
Allowing for surplus P and K applied to maize				**24**

Notes

1) Fresh FYM applied in spring, N availability 20% of total N. Maize is responsive to potash at soil K Index 1, so manure use is planned on the basis of 'available' K_2O content.
2) Where soil P Index 2, P_2O_5 requirement for maintenance of soil reserves.
3) Where P_2O_5 requirement is for maintenance, total P_2O_5 content of manure used in calculations.
4) To encourage rapid early growth, 10–15 kg/ha of the N requirement may be placed below the seed at drilling.
5) Assuming : N = 30 p/kg; P_2O_5 = 30 p/kg ; K_2O = 20 p/kg (based on recent inorganic fertiliser prices).

How to obtain more information

The following are available FREE, unless otherwise stated.

- Fertiliser Recommendations for Agricultural and Horticultural Crops (MAFF, RB 209) *Comprehensive reference book on use of organic manures and inorganic fertilisers. Seventh edition 2000, available from The Stationery Office – (£15) ISBN 0-11-243058-9.*

Available from ADAS Gleadthorpe Research Centre. Tel: 01623 844331

- Managing Livestock Manures: Booklet 1 – Making better use of livestock manures on arable land *(Second edition)*. ADAS, IGER, SRI
- Managing Livestock Manures: Booklet 3 – Spreading systems for slurries and solid manures. SRI, ADAS, IGER

Available from MAFF. Tel: 020 7238 6220

- MAFF/WOAD – Farm Waste Management Plan: A step-by-step guide for farmers.

Available from MAFF publications. Tel: 0645 556000

- The Water Code (Code of Good Agricultural Practice for the Protection of Water) – PB 0587. *Information on farm waste management plans and avoiding water pollution.*
- The Air Code (Code of Good Agricultural Practice for the Protection of Air) – PB 0618. *Information on farm waste treatment, minimising odours and ammonia losses.*
- The Soil Code (Code of Good Agricultural Practice for the Protection of Soil) – PB 0617. *Information on soil fertility, erosion and contamination.*
- Guidelines for Farmers in NVZs (PB 3277) and Manure Planning in NVZs (PB 3577)

Available from local Health and Safety Executive offices.

- HSE Preventing Access to Effluent Storage and Similar Areas on Farms. HSE Information sheet AIS 9.
- HSE Managing Confined Spaces on Farms. HSE Information Sheet AIS 26.
- HSE Occupational Health Risks from Cattle. HSE Information Sheet AIS 19.

- **National Farm Waste Management Plan Register** – a list of local consultants who can provide professional advice on waste management planning. Tel: 01398 361566
- **MANNER** (ADAS MANure Nitrogen Evaluation Routine) is a simple, personal computer-based decision-support system, supplied on CD-ROM or disk, with full instructions and a User Guide. It can be obtained free of charge from:
  ADAS Gleadthorpe Research Centre, Meden Vale, Mansfield, Nottingham, NG20 9PF
  Tel: 01623 844331 Fax: 01623 844472 or www.adas.co.uk/manner

Appendix A

Typical quantities of excreta produced by livestock during housing period

Type of Livestock	Age (Range or average)	Body weight kg	Excreta analysis DM %	Excreta analysis N kg/m³	% of year housed	Collection of excreta during housing period Daily kg or l	Collection of excreta during housing period Annual t or m³
Dairy cow		650	10	5.0	50	64	11.6
Dairy cow		550	10	5.0	50	53	9.6
Dairy cow		450	10	5.0	50	42	7.6
Grower/fattener	>2 yrs	500	10	5.0	25(1)	32	2.9
Grower/fattener	1–2 yrs	400	10	5.0	66(1)	26	6.2
Grower/fattener	0.5–1 yr	180	10	5.0	50(1)	13	2.4
Calf	0–0.5 yr	100	10	5.5	50(1)	7	1.3
Maiden gilts		90–130	6	5.0	100(2)	7.1	2.6
Sow place + litters	Progeny to 7 kg	130–225	6	5.0	100(3)	10.9	4.0
Weaners	3–7.5 wk	7–18	10	7.0	90	1.3	0.45
Growers, dry meal	7.5–11 wk	18–35	10	7.0	90	2.7	0.9
Light cutter, dry meal	11–20 wk	35–85	10	7.0	90	4.1	1.35
Bacon, meal fed	11–23 wk	35–105	10	7.0	90	4.5	1.5
Bacon, liquid fed (@ 4:1)	11–23 wk	35–105	6	4.5	90	7.2	2.35
1000 Laying hens		2200	30	16	97	115	41.0
1000 Broilers	42 days	2200	60	30	76	60	16.5(4)

Notes:

1) 'Occupancy' for growing/fattening cattle variable on farms.
2) Maiden gilts, assuming all year round accommodation.
3) Sows based on 2.3 lactations, covering 23% of year and dry period 77% of year.
4) Broilers, output per 6.6 crops/year, 42-day cycle (76% occupancy).

Appendix B

Suppliers of on-farm slurry analysis equipment

Slurry N meter and hydrometer:

- **Rekord Sales (G.B.) Ltd.**, Manor Road, Mancetter, Atherstone, Warwickshire.
  Tel: 01827 712424.
- **Qualex Limited**, 51 Dauntsey, Chippenham, Wiltshire SN15 4HN.
  Tel: 01249 890317.
- **Martin Sykes**, Cwm Wyntell, Letterston, Haverfordwest, Dyfed.
  Tel: 01348 840420.

Conversion table

Volumes

1 imperial gallon (gall) = 0.0045 cubic metre (m^3)	1 m^3 = 220 gall
1 imperial gallon (gall) = 4.55 litres (l)	1 litre = 0.22 gallons

Length

1 foot (ft) = 0.31 metre (m)	1 m = 3.28 ft

Speed

1 mile per hour (mph) = 1.61 kilometres per hour (km/h)	1 km/h = 0.62 mph
1 mile per hour (mph) = 0.45 metres per second (m/s)	1 m/s = 2.24 mph

Application rates

1 imperial gallon per acre (gall/ac) = 0.011 cubic metres per hectare (m^3/ha)	1m^3/ha = 90 gall/ac
1 ton per acre (ton/ac) = 2.50 tonnes/hectare (t/ha)	1 t/ha = 0.40 ton/ac

Area

1 acre (ac) = 0.405 hectares (ha)	1 ha = 2.47 ac

Fertilisers

1 unit per acre (unit/ac) = 1.25 kilograms/hectare (kg/ha)	1 kg/ha = 0.8 units/ac
1 kg P = 2.29 kg P_2O_5	1 kg P_2O_5 = 0.44 kg P
1 kg K = 1.20 kg K_2O	1 kg K_2O = 0.83 kg K
1 kg S = 2.50 kg SO_3	1 kg SO_3 = 0.40 kg S
1 kg Mg = 1.66 kg MgO	1 kg MgO = 0.60 kg Mg

What to do – a quick reference guide

The key management actions are outlined below:

- **Know the nutrient content of applied manures.**
- **Apply manures evenly and at known rates.**
- **Rapidly incorporate manures (where appropriate) or use an application technique that will minimise ammonia losses.**
- **Apply manures in spring (where possible) to reduce nitrate leaching losses.**
- **Take the nutrient supply from manures into account when calculating inorganic fertiliser additions.**

By following these steps manures will be used efficiently, without compromising crop yields and quality, and you will greatly reduce the risks of environmental pollution.