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Making better use of livestock manures on arable land

Booklet 1

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

Funded by the Ministry of Agriculture, Fisheries and Food

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NEW RECOMMENDATIONS

2nd edition 2001

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 for arable crop production
- calculate appropriate manure spreading rates
- minimise nutrient losses to air and water
- make savings on inorganic fertiliser use.

Booklet 1

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 21.

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 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.

Contents

Benefits of better manure use on arable land

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 other major nutrients sulphur (S), magnesium (Mg) and trace elements. Based on recent prices for N, P and K fertilisers, the slurry produced by a 1000-place finishing pig unit has a potential value of around £5,000/annum and from a 50,000-bird laying hen unit approximately £15,000/annum. The benefits of manures to soil organic matter status and the physical fertility of arable soils are also important.

Bearing in mind the overall costs of manure management, it is well worthwhile taking a little extra trouble to achieve the financial benefits of better nutrient management and at the same time reduce pollution risks.

Understanding nutrient losses

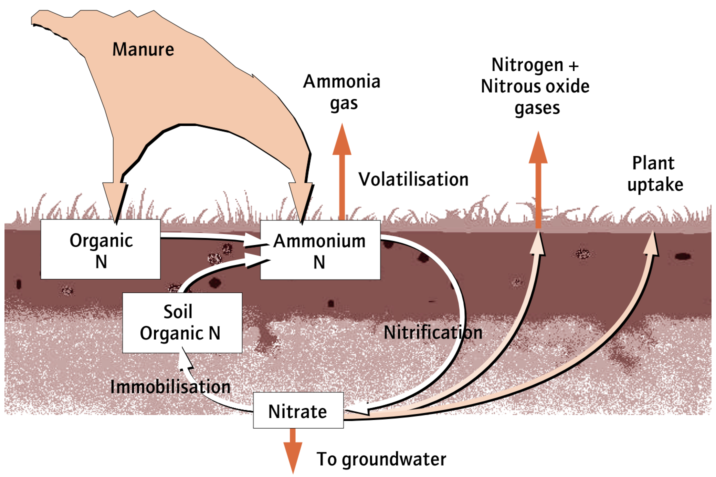
Two types of pollution can arise from manures, both of which result in nutrient losses.

1 'Point source' water pollution can occur through direct contamination of a watercourse from a burst or overflowing slurry store, or yard run-off 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 and 30,000 mg/l (parts per million) for slurries, compared with 300 to 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 a particular action or event, and may have long-term effects on the environment.

Nitrogen is readily lost from manures, either dissolved in water or as a gas. (See **Figure 1**.) Nitrogen is present in manures in mineral and organic forms.

Figure 1 Nitrogen cycle, showing main transformations and losses



The mineral N is largely 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.

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 can be deposited either nearby or transported long distances in the atmosphere. Ammonia deposition can contribute to soil acidification problems, particularly in woodland soils. It can raise N levels in nutrient-poor soils, such as botanically-rich habitats in old meadows and heathlands, so changing the types of plants that grow there. Deposited ammonia can also 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. 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) and *nitrogen gas* (N_2) are produced by soil microbial processes (denitrification). Nitrous oxide is one of the gases responsible for the 'greenhouse effect', whilst nitrogen gas is harmless to the environment. Both can be produced from the breakdown of nitrate in the soil, whether derived from manures, inorganic fertilisers or the soil itself, but the presence of manure encourages this process.
- *Phosphorus* is the main cause of algal blooms in freshwater systems, which can be damaging to aquatic life and unsightly for water users. Phosphorus is normally held firmly in the soil, but excessive manure applications can result in unnecessary soil P enrichment, which at elevated topsoil P concentrations can result in P leaching to ground and surface waters. Also, P can be lost through soil erosion and from surface runoff of freshly applied manures.
- *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

You can estimate the volume of manure to be managed using guideline quantities on livestock excreta production (see **Appendix A**), on-farm estimates of bedding use, washwater volumes, yard areas contributing drainage to the slurry system and local rainfall data.

In practice, drainage and washwater collected in slurry systems can result in substantial slurry dilution, often doubling the excreta volume. 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 manure nutrient contents than rely on 'experience' or guess work. 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 are required to provide the most reliable information. It is important that sampling is carried out carefully, involving the collection of multiple samples from which the final sample for analysis is taken. 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 total P contents (see **Figure 2**). Equipment suppliers are listed in **Appendix B**.

Figure 2
Agros N meter and slurry hydrometer

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

Manure Type	Dry matter (%)	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Sulphur (SO_3)	Magnesium (MgO)
Solid manures				kg/t		
Cattle farmyard manure [1]	25	6.0	3.5	8.0	1.8	0.7
Pig farmyard manure [1]	25	7.0	7.0	5.0	1.8	0.7
Sheep farmyard manure [1]	25	6.0	2.0	3.0	ND	ND
Duck manure [1]	25	6.5	5.5	7.5	2.7	1.2
Layer manure	30	16	13	9	3.8	2.2
Broiler/turkey litter	60	30	25	18	8.3	4.2
Slurries/liquids				kg/m^3		
Dairy	2	1.5	0.6	2.0	0.4	0.4
	6	3.0	1.2	3.5	0.8	0.7
	10	4.0	2.0	5.0	1.1	1.0
Beef	2	1.0	0.6	1.5	0.4	0.4
	6	2.3	1.2	2.7	0.8	0.7
	10	3.5	2.0	3.8	1.1	1.0
Pig	2	3.0	1.0	2.0	0.5	0.3
	4	4.0	2.0	2.5	0.7	0.4
	6	5.0	3.0	3.0	0.9	0.5
Dirty water	<1.0	0.3	Trace	0.3	ND	ND
Separated cattle slurries (liquid portion)				kg/m^3		
Strainer box	1.5	1.5	0.3	2.2	ND	ND
Weeping wall	3.0	2.0	0.5	3.0	ND	ND
Mechanical separator	4.0	3.0	1.2	3.5	ND	ND

Notes

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

ND = No data.

To convert kg/t to units/ton, multiply by 2.

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

Using manures and fertilisers together

Nitrogen

To make optimum use of the N contained in organic manures, they should be applied at times of maximum crop uptake – generally during the late winter/spring period.

There are two major loss processes that reduce the efficiency of readily available manure N utilisation following land application:

- Ammonia volatilisation
- Nitrate leaching.

Ammonia volatilisation: Ammonia loss and odour nuisance can be reduced by manure incorporation into soils (see **Table 2**), or for slurries by the use of injectors and band spreaders. If FYM and poultry manure are left on the soil surface following land application, typically 65% and 35% of the readily available N they contain can be lost to the atmosphere as ammonia.

In the case of slurries, DM content has an important influence on ammonia losses – with a 6% DM slurry typically losing 20% more N than a 2% DM slurry. Reduced losses from low DM slurries are associated with more rapid infiltration into the soil, compared with high DM slurries which remain longer on the soil/plant surface.

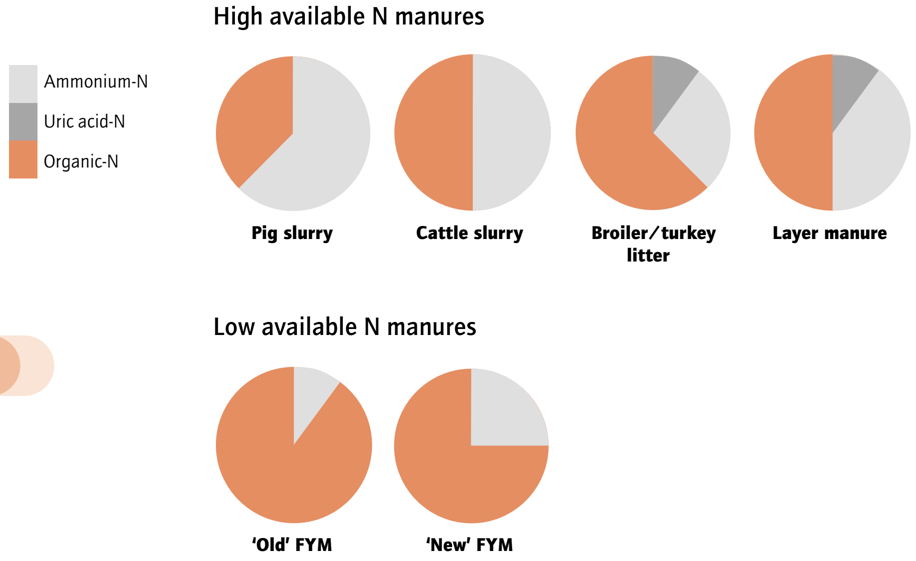
Table 2 Speed of manure incorporation required by ploughing to conserve readily available N

Manure type	Conservation target	
	90%	50%
Slurry	Immediate	6 hours
FYM	1 hour	24 hours
Poultry	6 hours	48 hours

Nitrate leaching: Livestock manures are the greatest source of avoidable nitrate leaching losses. The amount of N leached is mainly related to the manure application rate, readily available N content and timing of applications.

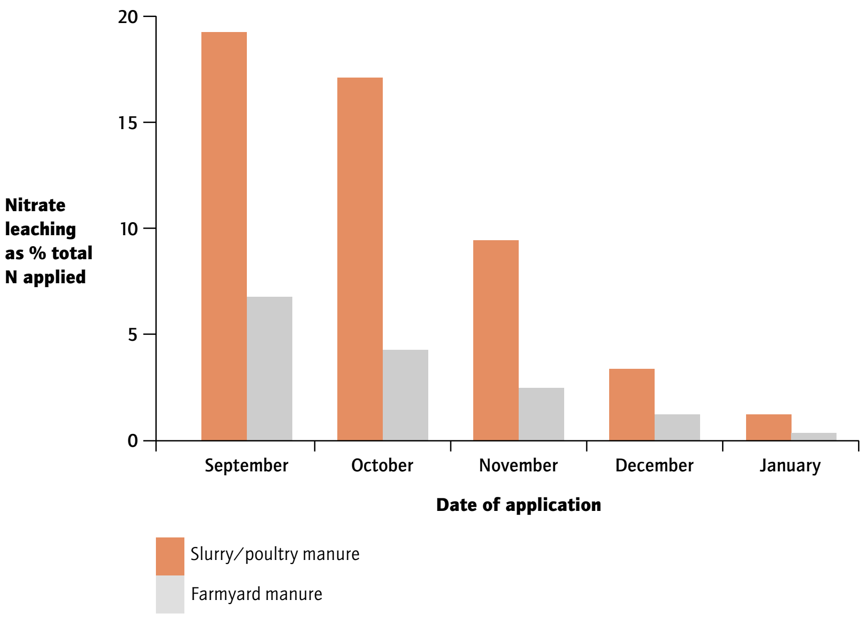
The ammonium (readily available) N content of manures is rapidly converted to nitrate-N and can then be used by plants or lost by leaching. (See **Figure 1**.) Slurries and poultry manures are 'high' in readily available N (40–60% of total N), compared with FYM which is 'low' in readily available N (10–25% of total N); see **Figure 3**. The rest of the N that manures contain is organic N which is released (mineralised) slowly over a period of months to years. In this way, around 10% of the total nitrogen content may become available for the second crop following application.

Figure 3 **Typical readily available N content of farm manures**



Where practically possible, applications during the autumn-early winter period should be avoided, as over winter rainfall is likely to wash nitrate out of the soil before crops can use it. Delaying applications, particularly of high available N manures, until the late winter or spring will increase the utilisation of manure N and reduce nitrate pollution. (See **Figure 4**.)

Figure 4 **Nitrate leaching losses following farm manure applications to free-draining arable soils**



Fertiliser value: The fertiliser value of manures is influenced by manure type, dry matter content, application timing/technique, soil type and weather patterns. The influence of these factors on N availability to the next crop grown is summarised in **Table 3** for surface applied manures, and in **Table 4** for the rapid soil incorporation of manures. The soil incorporated figures assume incorporation by ploughing 6 hours after application for slurries and 24 hours for solid manures. Cultivation using discs and tines is likely to be less effective than ploughing in minimising ammonia losses.

Table 3 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] Sandy/ shallow[2]	Autumn (Aug–Oct) [1] Medium/ heavy[2]	Winter (Nov–Jan) [1] Sandy/ shallow[2]	Winter (Nov–Jan) [1] Medium/ heavy[2]	Spring (Feb–Apr) All soils	Summer (May–July) All soils
Fresh FYM [3]	25	5	10	10	15	20	NA [4]
Old FYM [3]	25	5	10	10	10	15	NA [4]
Layer manure	30	10	20	15	30	35	NA [4]
Broiler/turkey litter	60	10	20	15	25	30	NA [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) NA – Not applicable, as there are few opportunities for solid manure applications in summer.
5) For separated cattle and pig slurries, use the 2% dry matter values..

Table 4 Percentage of total nitrogen available to the next crop following **soil incorporation** of livestock manures (% of total N)

Soil type/ manure type	Dry matter (%)	Timing: Autumn (Aug–Oct) [1] Sandy/ shallow[2]	Autumn (Aug–Oct) [1] Medium/ heavy[2]	Winter (Nov–Jan) [1] Sandy/ shallow[2]	Winter (Nov–Jan) [1] Medium/ heavy[2]	Spring (Feb–Apr) All soils
Fresh FYM [3]	25	5	10	10	15	20
Old FYM [3]	25	5	10	10	10	15
Layer manure	30	10	25	20	40	50
Broiler/turkey litter	60	10	25	20	40	45
Cattle slurry	2	5	20	25	45	55
	6	*5*	*20*	*20*	*35*	*45*
	10	5	15	15	30	35
Pig slurry	2	5	25	25	55	65
	4	*5*	*20*	*20*	*45*	*55*
	6	5	20	20	40	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).

Example

50 m^3/ha of 4% DM pig slurry containing 4.0 kg/m^3 total N, will supply 200 kg/ha total N. If this is applied in December to the surface of an arable stubble on a heavy textured soil, it will provide 80 kg/ha N (i.e. 40% of 200 kg/ha total N) towards the spring fertiliser N requirement of the next crop.

Figure 5 **ADAS MANNER – MANure Nitrogen Evaluation Routine**

Where more detailed field-specific guidance on the fertiliser N value of manures is required, use of the MANNER computer program is recommended (see **Figure 5**).

MANNER will predict the fertiliser N value of field applied manures, taking into account the manure type, manure analysis data (total N, ammonium N and uric-acid N), soil type, application timing and technique, ammonia and nitrate losses, and manure organic N mineralisation. MANNER is available free of charge from ADAS (see 'How to obtain more information' on page 21).

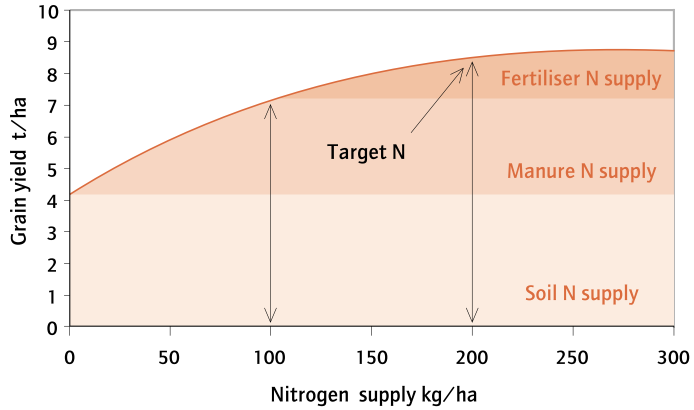
Soil mineral nitrogen: Where there is uncertainty about the level of residual mineral N present in the soil, such as following long-term manure use or where manures have been applied at unknown rates, sampling for soil mineral N (SMN) is recommended.

Soil samples should be taken to a depth of 60 cm, in two increments of 0–30 cm and 30–60 cm, and transported to the laboratory in a cool box or frozen for analysis. The SMN results will enable appropriate 'top-up' inorganic fertiliser N additions to be calculated for the next crop grown.

Manure and fertiliser N use: To make the best use of manure and inorganic fertiliser N inputs, an integrated policy is required. The aim should be to supply up to 50–60% of the crop's expected N requirement for optimum yield from the applied organic manure, with inorganic fertiliser N used to 'top up' crop needs.

A typical yield response curve for winter wheat in **Figure 6**, shows the crop responding up to an optimum rate of 200 kg/ha N. If half of this is supplied from

Figure 6 **Supplying winter wheat N requirement from manure and fertiliser sources**



manure (i.e. 100 kg/ha N) and the other half from inorganic fertiliser N, this will minimise the potential impact of variations in manure N supply, as crop N requirements will be at the 'top' of the yield response curve. Failure to allow adequately for the full N value of manures not only costs money in terms of wasted fertiliser N, but can compromise crop yields and quality, for example through lodging in cereals, depressed sugar levels in beet and reduced dry matters in potato tubers.

Phosphate and potash

Manures are valuable sources of plant available P and K, although short-term availability can be lower than from water-soluble P and K fertilisers.

Where crop responses to P and K are expected, e.g. ADAS soil Index 0 or 1 for combinable crops, or when responsive crops such as potatoes are grown, the *available* P and K content of the manure should be used to estimate manure P and K supply, and any additional need for inorganic P and K fertiliser additions. (See **Table 5**.)

However, where P and K applications are for maintenance of soil reserves, the *total* P and K content of the manure should be used. For most arable crops, typical manure application rates will supply all the P and K the crop needs.

Table 5 Phosphate and potash available to next crop (% total)

	Phosphate (P_2O_5)	Potash (K_2O)
Cattle/pig FYM	60	90
Poultry manure	60	90
Slurry/separated slurry	50	90
Dirty water	50	100

Over the crop rotation, manure P and K should be considered the same as inorganic P and K fertiliser in balance sheet calculations. At ADAS soil P Index 3 or above, take care to ensure that the total phosphate inputs in organic manures do not exceed that removed in crops during the rotation. This will avoid the soil P Index reaching an unnecessarily high level.

Sulphur and magnesium

On sulphur (S) deficient soil types, generally sandy and shallow soils in areas of low S deposition, yield responses to S fertiliser additions are becoming increasingly common in oilseed rape and cereals. Manures supply useful quantities of S and magnesium (Mg) (see **Table 1**), although there is only limited data on availability to the next crop grown.

However, for cattle slurry 50% sulphur availability has been measured in the season following application. The remaining organically bound sulphur will slowly become available to following crops. Magnesium inputs from manures should largely be regarded as contributing to the maintenance of soil reserves.

Soil conditioning benefits

Livestock manures, particularly solid manures, add useful amounts of organic matter to the soil, acting as a soil conditioner and structural improver. The water-holding capacity and drought resistance of light and heavy soils can be increased, though the greatest benefits are likely on sandy soils. Increased structural stability can be important on sandy and silty soils, particularly where small seeded crops are grown and where soil erosion by wind and water is a problem.

The biological activity of soils can be stimulated by manure additions and in some soils, earthworm numbers can be increased. Such improvements in soil physical and biological fertility are most likely to be achieved where regular manure applications are made.

Heavy metals

In addition to nutrients, livestock manures also contain heavy metals, which on certain soils, for example copper deficient soils, can correct a trace element deficiency. However, in the majority of situations, soil heavy metal accumulation is a more important issue. Pig and poultry manures can contain elevated levels of zinc and copper, which in the long term – over 100 years – may lead to undesirably high soil levels.

In situations where pig and poultry manures have been applied to land for a number of years, and will continue to be applied, it is advisable to have these soils analysed to determine their current heavy metal status and to monitor build-up periodically.

Odour nuisance

Complaints are commonly received about unpleasant smells from farms, especially from the spreading of manures. Avoid spreading in the evenings or at weekends when people are more likely to be at home, and pay attention to wind direction in relation to neighbouring houses. Slurry injection and rapid soil incorporation are effective methods of reducing odour and ammonia emissions.

Application rates

The MAFF Code of Good Agricultural Practice for the Protection of Water recommends that manure applications should not supply more than 250kg/ha total N per year. (See **Table 6**.) This is a sensible agronomic rate that will reduce pollution risks.

Table 6 Typical manure application rates to supply 250kg/ha total nitrogen

Manure type	% dry matter	Application rate (tonnes or m³/ha fresh weight)
Cattle FYM	25%	42
Pig FYM	25%	36
Dairy cattle slurry	6%	83
Pig slurry	4%	63
Layer manure	30%	16
Poultry litter	60%	8

Use of manures on arable crops

Manures can be applied to a wide range of arable crops; the main application periods are given in **Table 7**. Further practical recommendations are outlined below:

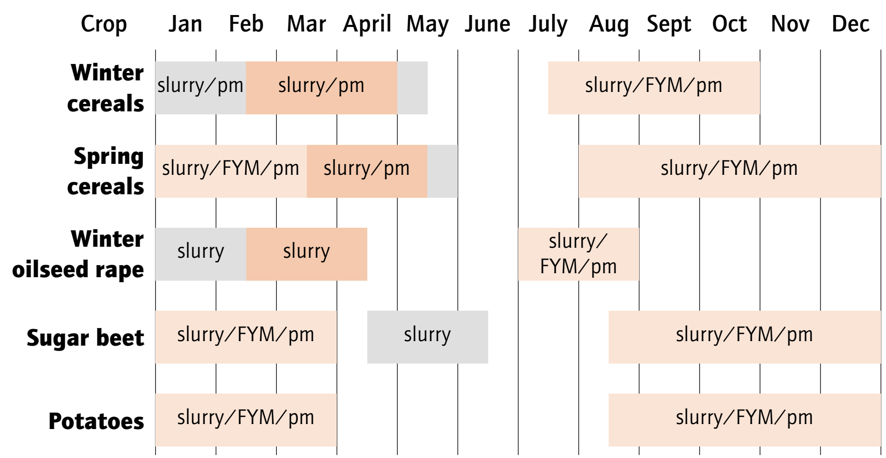
Winter cereals and winter oilseed rape

Manures are commonly applied to stubbles prior to drilling winter cereals and oilseed rape. Rapid incorporation, within a few hours (see **Table 2**), will minimise ammonia losses. However, to make best use of manure N and minimise nitrate leaching losses, high available N manures should be applied in late winter or spring.

Band spreaders are now available which enable slurry to be topdressed from tramlines (12–24 m bout widths) with precision and reduced ammonia emissions (about 30 – 40%) compared with conventional surface applications. See Booklet 3, *Spreading systems for slurries and solid manures*.

It is also possible to topdress poultry manures, although in many cases it will be necessary to 'split' tramlines, as machinery is not available that will consistently achieve satisfactory spread patterns across 12 m tramline widths.

Table 7 Timing strategies for manure applications on arable crops



opportunity for soil incorporation
optimum topdressing opportunity
possible topdressing opportunity, subject to soil conditions
pm poultry manures

Spring cereals and spring oilseed rape

Manure applications before spring cereals and oilseed rape should be made from January onwards to minimise nitrate leaching losses, particularly for high available N manures. Rapid incorporation will minimise ammonia losses. Slurries and poultry manures can also be topdressed following drilling.

Potatoes and sugar beet

Potatoes are a good crop on which to use the nutrients supplied by manures as the crop has high nutrient requirements. Particular care is needed with sugar beet as its nutrient requirements are modest. Manure management should be the same as for spring cereals. Excessive application rates, particularly of poultry manures, should be avoided, as this can depress tuber dry matters and in beet, root amino-N levels can be increased, depressing sugar yields.

Use in practice and financial benefits

Some worked examples are included below to demonstrate the principles described and potential for savings on inorganic fertiliser inputs. In these examples, it has been assumed that the crops are grown on medium soils, with soil P and K Indices of 2 and 2–, and that the previous crop was a cereal. (Soil Nitrogen Supply Index 1)

Example 1 Pig slurry applied as a topdressing in spring to winter wheat saves up to £85/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Financial saving[4]
1 Estimate total nutrients in slurry (kg/m³)				
Analysis of representative sample or reference to values in Table 1	4.0	2.0	2.5	
2 Estimate available nutrients in slurry (kg/m³)				
Table 3 as surface applied or MANNER for N	2.0 [1]			
Table 5 for P and K		1.0	2.2	
3 Nutrient requirement of winter wheat-straw incorporated (kg/ha)				
MAFF Fertiliser Recommendation book – RB 209 or other recognised system	220	60M [2]	45M [2]	
4 Calculate slurry nutrient supply				
Applied at 50 m³/ha, supplying 200 kg/ha total N	100	100 [3]	125 [3]	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – Stage 4	120	NIL	NIL	
6 Saving on NPK fertiliser inputs for *this crop*				**£57/ha**
7 Total saving on NPK fertiliser over crop *rotation*				
Allowing for surplus P and K applied				**£85/ha**

Notes

1) Pig slurry with 4% DM applied in spring; N availability 50% of total N (Table 3).
2) P and K fertiliser additions for maintenance (M) of soil reserves.
3) Soil P and K Indices of 2 and 2– ; total manure P and K contents used in calculations.
4) Assuming: N = 30 p/kg; P_2O_5 = 30 p/kg; K_2O = 20 p/kg.

Example 2 Cattle FYM applied in winter before sugar beet saves up to £117/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Financial saving[4]
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 fresh FYM (kg/t)				
Table 4 as rapidly incorporated or MANNER for N	0.9 [1]			
Table 5 for P and K		2.1	7.2	
3 Nutrient requirements of sugar beet (kg/ha)				
MAFF Fertiliser Recommendation book – RB 209 or other recognised system	100	50M [2]	100M [2]	
4 Calculate manure nutrient supply (kg/ha)				
Applied at 40 t/ha, supplying 240 kg/ha total N	36	140 [3]	320 [3]	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – Stage 4	64	NIL	NIL	
6 Saving on NPK fertiliser inputs for *this crop*				**£46/ha**
7 Total saving on NPK fertiliser over crop *rotation*				
Allowing for surplus P and K applied				**£117/ha**

Notes

1) Cattle FYM applied in winter to a medium soil and rapidly incorporated after 24 hours; N availability 15% of total N (Table 4).
2) P and K fertiliser additions for maintenance (M) of soil reserves.
3) Soil P and K Indices of 2 and 2– ; total manure P and K contents used in calculations.
4) Assuming : N = 30 p/kg ; P_2O_5 = 30 p/kg; K_2O = 20 p/kg.

Example 3 Broiler litter applied in spring before maincrop potatoes saves up to £120/ha

Stage and calculation procedure	N	P_2O_5	K_2O	Financial saving [3]
1 Estimate total nutrients in broiler litter (kg/t)				
Analysis of representative sample or reference to values in Table 1	30	25	18	
2 Estimate available nutrients in broiler litter (kg/t)				
Table 4 as rapidly incorporated or MANNER for N	13 [1]			
Table 5 for P and K		15	16	
3 Nutrient requirements of potatoes (kg/ha)				
MAFF Fertiliser Recommendation book – RB 209 or other recognised system	220	180	300	
4 Calculate manure nutrient supply (kg/ha)				
Applied at 8 t/ha, supplying 240 kg/ha total N	104	120 [2]	130 [2]	
5 Calculate inorganic fertiliser need (kg/ha)				
Stage 3 – Stage 4	116	60	170	
6 Saving on NPK fertiliser inputs for *this crop*				**£93/ha**
7 Total saving on NPK fertiliser inputs over crop *rotation*				
Allowing for total P and K applied				**£120/ha**

Notes

1) Broiler litter applied in spring and rapidly incorporated after 24 hours; N availability 45% of total N (Table 4).

2) Soil P and K Indices of 2 and 2–; as potatoes are a responsive crop to P fertiliser additions and have a high demand for K, the available P and K content of the broiler litter was calculated in the potato fertiliser programme, although, the total manure P and K content will be useful over the crop rotation.

3) Assuming: N = 30 p/kg; P_2O_5 = 30 p/kg; K_2O = 20 p/kg.

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 2 – Making better use of livestock manures on grassland *(Second edition).* IGER, ADAS, 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)	1 m^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.