Managing Livestock Manures

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

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.
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.

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 (NH₃) 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 (NO₃) 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
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 (P₂O₅), potash (K₂O), sulphur (SO₃) 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.
- 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.

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

<table>
<thead>
<tr>
<th>Manure Type</th>
<th>Dry matter (%)</th>
<th>Nitrogen (N)</th>
<th>Phosphate (P₂O₅)</th>
<th>Potash (K₂O)</th>
<th>Sulphur (SΟ₃)</th>
<th>Magnesium (MgO)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solid manures</strong></td>
<td></td>
<td>kg/t</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle farmyard manure (1)</td>
<td>25</td>
<td>6.0</td>
<td>3.5</td>
<td>8.0</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Pig farmyard manure (1)</td>
<td>25</td>
<td>7.0</td>
<td>7.0</td>
<td>5.0</td>
<td>1.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Sheep farmyard manure (1)</td>
<td>25</td>
<td>6.0</td>
<td>2.0</td>
<td>3.0</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Duck manure (1)</td>
<td>25</td>
<td>6.5</td>
<td>5.5</td>
<td>7.5</td>
<td>2.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Layer manure</td>
<td>30</td>
<td>16</td>
<td>13</td>
<td>9</td>
<td>3.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Broiler/turkey litter</td>
<td>60</td>
<td>30</td>
<td>25</td>
<td>18</td>
<td>8.3</td>
<td>4.2</td>
</tr>
<tr>
<td><strong>Slurries/liquids</strong></td>
<td>kg/m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>2</td>
<td>1.5</td>
<td>0.6</td>
<td>2.0</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3.0</td>
<td>1.2</td>
<td>3.5</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>4.0</td>
<td>2.0</td>
<td>5.0</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Beef</td>
<td>2</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2.3</td>
<td>1.2</td>
<td>2.7</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>3.5</td>
<td>2.0</td>
<td>3.8</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Pig</td>
<td>2</td>
<td>3.0</td>
<td>1.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4.0</td>
<td>2.0</td>
<td>2.5</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>5.0</td>
<td>3.0</td>
<td>3.0</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Dirty water</td>
<td>&lt;1.0</td>
<td>0.3</td>
<td>Trace</td>
<td>0.3</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>Separated cattle slurries (liquid portion)</strong></td>
<td>kg/m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strainer box</td>
<td>1.5</td>
<td>1.5</td>
<td>0.3</td>
<td>2.2</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Weeping wall</td>
<td>3.0</td>
<td>2.0</td>
<td>0.5</td>
<td>3.0</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Mechanical separator</td>
<td>4.0</td>
<td>3.0</td>
<td>1.2</td>
<td>3.5</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

**Notes**
1) Values of N and K₂O 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/m³ to units/1000 gallons, multiply by 9.

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

<table>
<thead>
<tr>
<th>Manure type</th>
<th>Conservation target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry</td>
<td>Immediate</td>
</tr>
<tr>
<td>FYM</td>
<td>1 hour</td>
</tr>
<tr>
<td>Poultry</td>
<td>6 hours</td>
</tr>
</tbody>
</table>
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.

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.)

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)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Fresh FYM (3)</td>
<td></td>
<td></td>
<td>25</td>
<td>5</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Old FYM (3)</td>
<td></td>
<td></td>
<td>25</td>
<td>5</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Layer manure</td>
<td></td>
<td></td>
<td>30</td>
<td>10</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Broiler/turkey litter</td>
<td></td>
<td></td>
<td>60</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Cattle slurry (5)</td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>6</td>
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<td>30</td>
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<td></td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>20</td>
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<tr>
<td>Pig slurry (5)</td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>25</td>
<td>60</td>
</tr>
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<td></td>
<td>4</td>
<td>5</td>
<td>50</td>
<td>60</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>5</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Dirty water</td>
<td></td>
<td></td>
<td>&lt;1</td>
<td>0</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>10</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

### 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)

<table>
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</thead>
<tbody>
<tr>
<td>Fresh FYM (3)</td>
<td></td>
<td></td>
<td>25</td>
<td>5</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Old FYM (3)</td>
<td></td>
<td></td>
<td>25</td>
<td>5</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Layer manure</td>
<td></td>
<td></td>
<td>30</td>
<td>10</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Broiler/turkey litter</td>
<td></td>
<td></td>
<td>60</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Cattle slurry</td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>5</td>
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<td>35</td>
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<td>10</td>
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<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Pig slurry</td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>5</td>
<td>20</td>
<td>60</td>
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<td></td>
<td></td>
<td>6</td>
<td>5</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Dirty water</td>
<td></td>
<td></td>
<td>&lt;1</td>
<td>0</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>10</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

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5. For separated cattle and pig slurries, use the 2% dry matter values.

### Example

50 m³/ha of 4% DM pig slurry containing 4.0 kg/m³ 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.
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 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.
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.
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.

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.

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

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

### Table 7  Timing strategies for manure applications on arable crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>slurry/FYM/pm</td>
<td>slurry/pm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring cereals</td>
<td>slurry/FYM/pm</td>
<td>slurry/pm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter oilseed rape</td>
<td>slurry</td>
<td>slurry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar beet</td>
<td>slurry/FYM/pm</td>
<td>slurry</td>
<td>slurry/FYM/pm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>slurry/FYM/pm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*pm* poultry manures
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

1. Estimate total nutrients in slurry (kg/m³)
   Analysis of representative sample or reference to values in Table 1
   N = 4.0, P₂O₅ = 2.0, K₂O = 2.5

2. Estimate available nutrients in slurry (kg/m³)
   Table 3 as surface applied or MANNER for N
   Table 5 for P and K
   N = 2.0 (1)
   P₂O₅ = 1.0
   K₂O = 2.2

3. Nutrient requirement of winter wheat-straw incorporated (kg/ha)
   MAFF Fertiliser Recommendation book – RB 209 or other recognised system
   N = 220, P₂O₅ = 60M (2), K₂O = 45M (2)

4. Calculate slurry nutrient supply
   Applied at 50 m³/ha, supplying 200 kg/ha total N
   N = 100, P₂O₅ = 100 (3), K₂O = 125 (3)

5. Calculate inorganic fertiliser need (kg/ha)
   Stage 3 – Stage 4
   N = 120, P₂O₅ = NIL, K₂O = 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; P₂O₅ = 30 p/kg; K₂O = 20 p/kg.

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

Stage and calculation procedure

1. Estimate total nutrients in FYM (kg/t)
   Analysis of representative sample or reference to values in Table 1
   N = 6.0, P₂O₅ = 3.5, K₂O = 8.0

2. Estimate available nutrients in fresh FYM (kg/t)
   Table 4 as rapidly incorporated or MANNER for N
   Table 5 for P and K
   N = 0.9 (1)
   P₂O₅ = 2.1
   K₂O = 7.2

3. Nutrient requirements of sugar beet (kg/ha)
   MAFF Fertiliser Recommendation book – RB 209 or other recognised system
   N = 100, P₂O₅ = 50M (2), K₂O = 100M (2)

4. Calculate manure nutrient supply (kg/ha)
   Applied at 40 t/ha, supplying 240 kg/ha total N
   N = 36, P₂O₅ = 140 (3), K₂O = 320 (3)

5. Calculate inorganic fertiliser need (kg/ha)
   Stage 3 – Stage 4
   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; P₂O₅ = 30 p/kg; K₂O = 20 p/kg.
Example 3  Broiler litter applied in spring before maincrop potatoes saves up to £120/ha

<table>
<thead>
<tr>
<th>Stage and calculation procedure</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>Financial saving (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Estimate total nutrients in broiler litter (kg/t)</td>
<td>30</td>
<td>25</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Analysis of representative sample or reference to values in Table 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Estimate available nutrients in broiler litter (kg/t)</td>
<td>13(1)</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Table 4 as rapidly incorporated or MANNER for N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 5 for P and K</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Nutrient requirements of potatoes (kg/ha)</td>
<td>220</td>
<td>180</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>MAFF Fertiliser Recommendation book – RB 209 or other recognised system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Calculate manure nutrient supply (kg/ha)</td>
<td>104</td>
<td>120(2)</td>
<td>130(2)</td>
<td></td>
</tr>
<tr>
<td>Applied at 8 t/ha, supplying 240 kg./total N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Calculate inorganic fertiliser need (kg/ha)</td>
<td>116</td>
<td>60</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>Stage 3 – Stage 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Saving on NPK fertiliser inputs for this crop</td>
<td>£93/ha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Total saving on NPK fertiliser inputs over crop rotation</td>
<td>£120/ha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowing for total P and K applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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; P₂O₅ = 30 p/kg; K₂O = 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.
  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
  Available from MAFF publications. Tel: 0645 556000
- 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.
- 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

<table>
<thead>
<tr>
<th>Type of Livestock</th>
<th>Age (Range or average)</th>
<th>Body weight kg</th>
<th>Excreta analysis DM %</th>
<th>Bodyweight N kg/m³</th>
<th>% of year housed</th>
<th>Collection of excreta during housing period Daily kg or l</th>
<th>Annual t or m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cow</td>
<td>650</td>
<td>10 5.0</td>
<td>50</td>
<td>64</td>
<td>11.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy cow</td>
<td>550</td>
<td>10 5.0</td>
<td>50</td>
<td>53</td>
<td>9.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy cow</td>
<td>450</td>
<td>10 5.0</td>
<td>50</td>
<td>42</td>
<td>7.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower/fattener (&gt;2 yrs)</td>
<td>500</td>
<td>10 5.0</td>
<td>25¹</td>
<td>32</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower/fattener (1–2 yrs)</td>
<td>400</td>
<td>10 5.0</td>
<td>66¹</td>
<td>26</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower/fattener (0.5–1 yr)</td>
<td>180</td>
<td>10 5.0</td>
<td>50¹</td>
<td>13</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calf</td>
<td>100</td>
<td>10 5.5</td>
<td>50¹</td>
<td>7</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maiden gilts</td>
<td>90–130</td>
<td>6 5.0</td>
<td>100²</td>
<td>7.1</td>
<td>2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sow place + litters</td>
<td>Progeny to 7 kg</td>
<td>130–225</td>
<td>6 5.0</td>
<td>10.9</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaners</td>
<td>3–7.5 wk</td>
<td>7–18</td>
<td>10 7.0</td>
<td>1.3</td>
<td>0.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growers, dry meal</td>
<td>7.5–11 wk</td>
<td>18–35</td>
<td>10 7.0</td>
<td>2.7</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light cutter, dry meal</td>
<td>11–20 wk</td>
<td>35–85</td>
<td>10 7.0</td>
<td>4.1</td>
<td>1.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacon, meal fed</td>
<td>11–23 wk</td>
<td>35–105</td>
<td>10 7.0</td>
<td>4.5</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacon, liquid fed (at 4:1)</td>
<td>11–23 wk</td>
<td>35–105</td>
<td>6 4.5</td>
<td>7.2</td>
<td>2.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000 Laying hens</td>
<td>2200</td>
<td>30 16</td>
<td>97</td>
<td>115</td>
<td>41.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000 Broilers</td>
<td>2200</td>
<td>60 30</td>
<td>76</td>
<td>60</td>
<td>16.5³</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
Volumes

1 imperial gallon (gall) = 0.0045 cubic metre (m³)  
\[1 \text{ m}^3 = 220 \text{ gall}\]
1 imperial gallon (gall) = 4.55 litres (l)  
\[1 \text{ litre} = 0.22 \text{ gallons}\]

Length

1 foot (ft) = 0.31 metre (m)  
\[1 \text{ m} = 3.28 \text{ ft}\]

Speed

1 mile per hour (mph)  
\[= 1.61 \text{ kilometres per hour (km/h)}\]
\[1 \text{ km/h} = 0.62 \text{ mph}\]
1 mile per hour (mph)  
\[= 0.45 \text{ metres per second (m/s)}\]
\[1 \text{ m/s} = 2.24 \text{ mph}\]

Application rates

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

Area

1 acre (ac) = 0.405 hectares (ha)  
\[1 \text{ ha} = 2.47 \text{ ac}\]

Fertilisers

1 unit per acre (unit/ac)  
\[= 1.25 \text{ kilograms/hectare (kg/ha)}\]
\[1 \text{ kg/ha} = 0.8 \text{ units/ac}\]
1 kg P = 2.29 kg P₂O₅  
\[1 \text{ kg P}_2\text{O}_5 = 0.44 \text{ kg P}\]
1 kg K = 1.20 kg K₂O  
\[1 \text{ kg K}_2\text{O} = 0.83 \text{ kg K}\]
1 kg S = 2.50 kg SO₃  
\[1 \text{ kg SO}_3 = 0.40 \text{ kg S}\]
1 kg Mg = 1.66 kg MgO  
\[1 \text{ kg MgO} = 0.60 \text{ kg Mg}\]

Conversion table

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.