Understanding your options: getting more N out of manure

Agricultural manure and slurry is a valuable source of nutrients. However, farmers are often uncertain about how much of the nitrogen (N) in manure and slurries applied to land is actually available for crop uptake. **This article provides new information that will help farmers understand how to make more of the N in agricultural manure and slurry available to crops by using ammonia-reducing spreading techniques and anaerobic digestion (AD).** This is important information for nutrient management planning and optimising the efficiency of mineral N fertiliser applications.

Key recommendations

- *Applying slurry by techniques that reduce ammonia emissions can be a cost-effective means of getting more slurry N into crops.*
- *There may also be benefits in improving silage quality and reducing the interval between slurry application and grazing.*
- *Using AD for slurries may also increase the uptake of manure N by crops, especially when the digested slurry is applied by techniques that reduce ammonia emissions.*

Background information

The Defra Fertiliser Manual RB209 (available on the Defra website (www.defra.gov.uk/publications/2011/03/25/fertiliser-manual-rb209/) provides guidance on how to ensure that proper account is taken of mineral fertilisers and other sources of nutrients, such as agricultural manure and slurry, so helping prevent costly over application. RB209 also provides useful information on how applying manures in spring can increase the amount of manure N that remains available for crops.

'..losses of crop-available N as ammonia following application to land can be large and will vary greatly according to the method of application, soil conditions, crop growth at the time of application and weather conditions'

The principle of 'closed periods' for applying slurry and poultry manure in Nitrate Vulnerable Zones (NVZs) has been recognised as good practice for many years and has reduced the risk of crop-available manure N being lost through nitrate leaching. However, losses of crop-available N as ammonia following application to land can be large and will vary greatly according to the method of application, soil conditions, crop growth at the time of application and weather conditions. It is worth remembering that, even if manure is analysed for N content at the end of the storage period, the measurement of available N will not take into account losses following application.

Assessment of application techniques

In recent years, more UK farmers have started to apply slurry using machines that are designed to reduce ammonia emissions and conserve crop-available N. These are typically shallow injection machines and band spreaders (trailing hose and trailing shoe). While there may be other reasons why farmers have adopted these spreading practices (e.g. in some parts of England, pig farmers apply slurry by injection to reduce complaints about odour), one of the most important benefits is the reduction in ammonia emissions, which represents a waste of N that would

'..one of the most important benefits is the reduction in ammonia emissions, which represents a waste of N that would otherwise be available for crop uptake.'

otherwise be available for crop uptake. In addition, emissions of ammonia are very variable and lead to differences in the amounts of crop-available N that may be added to soil in manures. When slurries and solid manures are applied to arable land, rapid incorporation into the soil by ploughing greatly reduces emissions of ammonia. By reducing ammonia emissions, much of the uncertainty over the amounts of N available for crop uptake is removed, making the manure a more reliable and predictable source of N for crops.
For example, consider an application of 50 m^3 per hectare (ha) of cattle slurry applied in spring to grass to be cut for silage. Typically, this will apply around 60 kg of available N per ha. On average, 16 kg/ha of this available N will be lost as ammonia when the slurry is applied to the soil surface. At the current price of fertiliser N, this is equivalent to a loss of around £15/ha. However, if the slurry is injected into the soil, ammonia emissions will be reduced by about 70%, conserving 11 kg/ha of available N. Studies have shown that, generally, the additional N available to crops is equivalent to the reduction in emissions of ammonia N, so an additional 11 kg/ha are available for crop uptake.

While many farmers may think that the cost of injection or trailing shoe machines outweighs the benefits these machines offer, a recent study by environmental consultancy AEA and Creedy Associates (Webb et al., 2010), found that the value of manure N conserved by reducing ammonia emissions may make the use of injection or trailing shoe cost-effective. These machines are more cost-effective when used on farms that produce large volumes of manure. The exact cost-to-benefit ratio will vary from farm to farm and depends on a number of factors, mainly the current cost of N fertiliser and the volume of slurry to be spread. Table 1 gives examples of the costs and benefits of applying slurry by reduced-emission techniques based on the additional costs of slurry applied by contractors using reduced ammonia emission machines.

'The value of manure N conserved by reducing ammonia emissions may make the use of injection or trailing shoe cost-effective'

Table 1: Estimates of the value of pig-slurry N conserved by reduced-emission slurry application

Application method:	Surface	Trailing shoe	Slot injection	*Other
Slurry volume (m^3) per hectare	30	30	30	50
N applied (kg per hectare)	108	108	108	180
Ammonia emission (kg N per hectare)	20	8	6	1.6
% abatement	0	60	70	95
N conserved (kg per hectare)	0	11.9	13.8	31.1
Value of extra N available (£ per 30 m^3 slurry) (50 m^3 for immediate incorporation)	0	11.5	13.4	30.2
Value of extra N uptake (£ per m^3 slurry)	0	0.38	0.45	0.60
Additional cost of abatement by contractor(£ per m^3 slurry)		0.42	0.42	0.54
Net cost (£ per m^3 slurry)		**0.04**	**-0.03**	**-0.06**

Based on:

- Slurry at 4% dry matter and 70% of total N available for crop uptake.
- Price of £335 per tonne of ammonium nitrate (April 2012 price). This equates to £0.97per kg N.

*immediate incorporation by plough

'..application of manure via direct injection and immediate incorporation would conserve enough available N to justify the additional costs. There may be other benefits (e.g. earlier turn out on grazed land and improved silage quality)

This shows that, at present prices, while the value of crop-available N conserved by applying manure via a trailing shoe does not fully meet the additional cost of using these machines, application of manure via direct injection and immediate incorporation would conserve enough available N to justify the additional costs. There may be other benefits (e.g. earlier turn out on grazed land and improved silage quality), but these are less readily quantifiable.

This study of Webb et al. (2010) also highlights that although ammonia emissions are reduced more by immediate incorporation of slurry by plough (by around 90%) than by injection (70-80% reduction) or trailing shoe (60-70% reduction), more slurry N was recovered by crops when applied in bands by injection or trailing shoe than when it was incorporated into arable land by cultivation. This is because incorporating manure into soil by cultivation leads to greater mixing and more opportunities for N uptake by microbes (immobilisation), which reduces the proportion of potentially available N that can be taken up by crops. However, when slurry is added to soil in bands, the potential for immobilisation is reduced, but still allows crop roots to have easy access to the N.

'On arable land, the best option to reduce ammonia emissions following slurry spreading is to incorporate as soon as possible after spreading.'

On arable land, the best option to reduce ammonia emissions following slurry spreading is to incorporate as soon as possible after spreading. Incorporation by ploughing is the best option as it is the most effective means of reducing ammonia emissions and will tend to mix soil and manure more than some other forms of incorporation. However, it seems that slurry application by injector or trailing shoe may be at least as effective in increasing crop uptake of manure N as application followed by immediate incorporation.

Applying slurry to grassland by shallow injection and trailing shoe can increase the flexibility of slurry management by allowing more spreading at shorter intervals before cutting grass (compared with conventional surface broadcasting), without detriment to silage quality. Overall, the trailing shoe appears to be a better application method than injection because it leads to less sward damage and herbage contamination, but produces crop N uptake similar to that achieved with injection. Similar effects have been reported with respect to the palatability of herbage. When slurry is applied to taller grass, there is a reduction in efficiency of application by injector and a decrease in palatability. However, when slurry is applied to shorter grass, following silage cutting, cattle respond equally well to pastures on which injection or trailing shoe are used, and both are better than surface application.

In recent years, there has been increased interest in AD of slurries, either alone or with other materials such as dilute food wastes. During digestion, some organic N is converted to plant-available organic forms. Typically, the proportion of crop-available N increases from 50-70% to 60-80% of total N. Field experiments have demonstrated that this extra crop-available N is taken up by crops. In addition, the easily broken down carbon compounds contained in slurry, which provide an energy source for microbes and, hence, encourage immobilisation of mineral N in soil, are converted to methane during digestion which is used for energy or fuel. As a result, immobilisation of available N in soil is reduced when slurry has been treated in an AD plant.

'..immobilisation of available N in soil is reduced when slurry has been treated in an AD plant.'

For further information on this or any other farm related query, please contact the Farming Advice Service, which provides free, integrated advice to help you improve the economic and environmental performance of your farm.

Further information on the application of agricultural manure and slurry can be found in Section 5.4 of the Defra Code of Good Agricultural Practice.

Farming Advice Service contacts

- Technical email: advice@farmingadviceservice.org.uk
- Technical helpline: **0845 345 1302**
- Website: www.defra.gov.uk/farming-advice
- Register for FAS text message updates and newsletters: bookings@farmingadviceservice.org.uk

Other sources of nutrient management advice:

Tried and Tested Think Manures – www.nutrientmanagement.org/Tools/Think-manures
Catchment Sensitive Farming – www.naturalengland.org.uk/ourwork/farming/csf/default.aspx

Reference

Webb J, Pain B, Bittman S, Morgan J. (2010). The impacts of manure application methods on emissions of ammonia, nitrous oxide and on crop response – A review. Agriculture Ecosystems and Environment 137, 39-46.