C. Low emission manure spreading techniques

Introduction

21. Ammonia emissions from the application of manures (slurries and solid manures such as farmyard manure and broiler litter) account for a large proportion of ammonia emissions from agriculture. It is very important to minimize losses at this stage of management because any ammonia saved earlier, from livestock housing or manure storage, might be lost if it is not controlled by an appropriate field application technique. Reducing ammonia loss means that more nitrogen is potentially available for crop uptake.

To gain the maximum agronomic benefit from manures, and to avoid increasing the risk of nitrate leaching, attention should be paid to the N content of the manure so that the rate, method and time of application is matched to crop requirements.

A. Reduced [emission techniques for slurries and other liquid manures

22. The most effective means of reducing ammonia emissions from slurry application is to employ an appropriate application technique such as an injector or band spreader.

Injectors: These reduce emissions by placing the manure beneath the soil surface, thus decreasing the manure surface area exposed to the air and increasing infiltration into the soil. They are generally more effective for reduction of ammonia emission than band spreaders. There are three types:

(a) Shallow (or slot) injectors: these cut narrow slots (typically 4-6 cm deep and 25-30 cm apart) in the soil that are filled with slurry or liquid manure. They are most commonly used on grassland. Different abatement results are achieved depending on whether open or closed slot injectors are used;

(b) Deep injectors: these apply slurry or liquid manure to a depth of 10 – 30 cm in the soil using injector tines spaced about 50 cm or even 75 cm apart. The tines are often fitted with lateral wings to aid dispersion in the soil and to achieve high application rates. They are most suited for use on arable land because of the risk of mechanical damage to grass swards;

(c) Arable injectors: these are based on spring or rigid tine cultivators and are for use on arable land only.

Band spreaders: These reduce emissions from slurries and liquid manures through decreasing the manure surface area exposed to the air and decreasing air flow over it. The efficiency of these machines can vary depending on the height of the crop. There are two main types of machine:

(a) Trailing hoses: slurry is discharged at ground level to grass or arable land through a series of flexible hoses. Application between the rows of a growing crop is feasible;

(b) Trailing shoes (or feet): slurry is normally discharged through rigid pipes which terminate in metal "shoes" designed to ride along the soil surface, parting the crop so that slurry is applied directly to the soil surface and below the crop canopy. Some types of trailing shoes are designed to cut a shallow slit in the soil to aid infiltration.

Incorporation

23. The aim should be to incorporate slurry into the soil as rapidly as possible after spreading on the surface. It is normally recommended that incorporation should be completed within, at most, 6 hours of spreading to achieve worthwhile abatement. Completely burying the slurry by ploughing is a slow operation and, in many cases, the use of a tine or disc cultivator may be as effective because the slurry will remain exposed on the surface for a shorter time before being well mixed with the soil by cultivation. []Incorpporation of solid manures is discussed below.

Dilution of slurry

24. Ammonia emissions from dilute slurry with low dry matter (DM) content are generally lower than for undiluted slurry because of faster infiltration into the soil.

Two options are available:

(1) Doses of slurry can be added to irrigation water to be applied onto grassland or growing crops on arable land. This is best done by injecting slurry into the irrigation water pipeline and pumped under low pressure to the sprinkler or travelling irrigator (not under high pressue to a big gun which sprays the mix onto land). Dilution rates may be up to 50:1 water:slurry, but at least 1:1, which may result in a emission reduction of 30 %

(2) Doses of water can be added to viscous slurries before application either in the slurry store or in the tank wagon. For viscous cattle slurries even dilution rates of 0,5:1 water:slurry can contribute to significant loss reduction of 30 %. However, the extra costs for the transportation of water are considerable and it is important, that the slurry dose is increased proportionally to the reduction of the TAN content.

Mechanical separation of slurry

25. Applying the liquid fraction from an efficient separating machine can give a considerable reduction in emissions of 20-30 % due to more rapid infiltration but only if the soil conditions support infiltration (e.g. not saturated or very compacted). Also, ammonia emissions take place from the solid fraction and in consequence total emissions may not always be lower. To minimize the emissions from the solid fraction frequently delivery to a biogas plant is advisable.

Acidification of slurry

26. High pH favours loss of ammonia. Lowering the pH of slurries to a stable level of 6 or less is commonly sufficient to reduce ammonia emission by 50% per cent or more. This can be achieved by adding sulphuric acid to slurry. A technique which automatically doses sulphuric acid during the application of slurry is now on the market in Denmark and practiced on farms with considerable success.

Application timing management systems (ATMS).

27. The following techniques can also help to reduce ammonia emissions from slurry application, although they may not be as effective or reliable as those outlined above:

(a)Time of application: Spreading under cool, windless and humid conditions, will help to minimize emissions;
(b) application shortly before rainfall (only effective if immediately after spreading rainfall of around 10 mm occurs; **only applicable on flat land and away from surface waterways because of run-off**)
(c) spreading in the evening, when wind speed and air temperature are decreasing
(d) spreading on freshly cultivated soils, provided that there is more rapid manure infiltration

Other Additives

28. The use of other additives apart from acids are either not proven to be effective or have practical problems that limit their use.

B. Low emission techniques for solid manures

29. Incorporation into the soil is the only practical technique for reducing emissions from solid manure although recently there has been some success in the USA with slot injectors for poultry litter. Most of the ammonia is released from solid manure within a few hours of spreading. It is recommended, therefore, that incorporation should take place within a few hours after spreading. Only in exceptional cases the lag should be up to a maximum of 24 hours. The manure must be completely mixed with soil or buried for maximum abatement and it is often more difficult to achieve this with some solid manures (e.g. those containing large amounts of straw) than with slurries.
Reductions of 60-90% of ammonia emissions can be achieved when solid manures are incorporated into arable land by plough within 4 h of application. In contrast to slurry, studies have shown that incorporation of solid manures by plough is always more effective than incorporation by disc or tine despite the slower work rate of ploughing. [See Webb et al. (2006)]
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C. Practical considerations

30. Effectiveness in reducing emissions, applicability and costs should be taken into account in selecting the most suitable techniques for reducing ammonia emissions. Guidance on the effectiveness and applicability of the different methods is given in Table 4.1. The reduction of emissions is expressed as a percentage of the reference method. The reference for manure application method is defined as the emission from untreated slurry or solid manure spread over the whole soil surface ("broadcast"). For slurry, this would be with a tanker equipped with a discharge nozzle and splash plate. For solid manure, the method would be to leave the manure on the soil surface for a week or more.

31. The following considerations can also help to achieve an optimal emission reduction:

- The effectiveness of abatement achieved with band spreaders and injectors will vary with the

dry matter content of the slurry, soil properties and crop characteristics.

- Similarly, the effectiveness of incorporation varies with the type of manure and the time since spreading.
- Band spreaders are, in general, more effective on arable than on grassland and when used with dilute pig slurries than with more viscous cattle slurries.
- Band spreaders and open slot injectors are not always suitable for use on steeply sloping land due to runoff potential and sub-surface injection techniques do not work well on very stony or compacted soils.
- Open slot injectors are more applicable to a wider range of soil types and conditions than closed slot machines.
- Small, irregularly shaped fields present difficulties for large machines.
- Incorporation is restricted to land that is cultivated.
- Umbilical systems, where the applicator is mounted directly on the tractor and fed from a tank or pipe via a long flexible hose, offer an alternative to mounting the applicator on a tractor-drawn tanker or tanker truck.They have the advantage of higher work rates and of lessening the risk of soil damage by compaction and can preferably be used on farms with small distances between slurry store and fields. However, it is time consuming to roll out hoses and roll them back in again.
- Dilution in irrigation systems is not widely applicable, but if irrigation is practiced, this can be a very affective measure for abating emissions.
- Diluting slurry in mobile systems is only practicable on small farms, since additional water to be spread reduces the spreading performance drastically and causes higher spreading costs.
- Capital and operating costs for low emission systems are likely to be more than for broadcast spreading techniques, but savings of mineral nitrogen fertilizer may compensate extra costs in many cases.
- The working width is limited for injectors, and the amount of damage from the wheels is relatively high. This must be considered, when used in grass and cereal.
- Acidification is normally done by mixing concentrated sulfuric acid into the slurry prior to or during application. However, sulfuric acid is a dangerous chemical, and must be handled by care.

Table 4.1. Practical considerations in selection of ammonia abatement techniques for landspreading manures.

Abatement technique	Manure type	Land use	Reduction in Emission %	Restriction on applicability
Trailing hoses	Slurry and other liquid manure	Grassland/ arable land	30-35%	Field slope, size and shape. Not highly viscous slurry. Width of tramlines for growing cereal crops. Height of crop is a factor that influences emission reduction on arable land, which leads to emission reduction
Trailing shoe	Slurry and liquid manure	Grassland and arable land (pre-seeding) and row crops crops	30-60%	As above. Not suitable for use in growing solid seeded crops but may be suitable for rosette stage of row crops
Shallow injection	Slurry and liquid manure	Grassland and arable land. Also on growing cereals	open slot 70%; closed slot 80% at 10cm depth;	As above. Not very dry, stony or very compacted soils
Deep injection (including arable injectors)	Slurry and liquid manure	Arable land	70–90%	As above. Needs high powered tractor. Not suitable on shallow soils, high clay soils (>35%) in very dry conditions, peat soils (>25% organic matter content) and perforated-tile drained soils that are susceptible to leaching
Active dilution of slurry for use in water irrigation systems	Slurry	Arable land and grassland	50% dilution =30 %	Only where irrigation is practiced. Only for low pressure irrigation systems
Dilution before spreading with mobile spreading systems	Particularly viscous cattle slurry	Arable land and grassland	Up to 50 % for viscous cattle slurries	Extra volume needed to be spread. Only for small farms and for irrigation. Dose must be increased proportionally to the reduction of the TAN content
Application timing management systems (ATMS).	All manure types	Arable land and grassland		This technique requires local validation

Incorporation into soil	Slurry	Arable land including new grass leys seedings. Only effective, if incorporation occurs right after application	Immediate ploughing 90%; Immediate non inversion cultivation 70%; incorporation within 4 h =45-65%; incorporation within 24 h =30%20-90%	Land that is cultivated,
Incorporation into soil	Solid manure	Arable land including grass Leys. Only effective, if incorporation occurs right after application	Immediate ploughing 90% Immediate non inversion cultivation 60%; incorporation within 4 h =45-65%; incorporation within 12 h =50%; incorporation within 24 h =30%	Land that is cultivated,