CHAPTER 26

Slurry Application on Grass

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Liquid manure, or slurry, is commonly under-utilized as a resource on livestock farms. Large proportions of the nutrients consumed by livestock in feed are usually excreted by animals in feces and urine. When collected and managed properly as either liquid or solid manures, these nutrients can be recycled very effectively to offset fertilizer costs on farms.

In Ireland, slurry is usually produced in livestock housing systems that avoid using additional bedding material. Rather than allowing manure to accumulate under animals, liquid slurry systems usually involve frequent removal of excrement from the floor or house by regular scraping, flushing with water, or by collection under slatted floors. Slurry systems are usually more common in cattle and swine systems than with poultry. In Ireland, approximately 80% of cattle manure (both beef and dairy) and almost 100% of swine manure is managed as liquid slurry. Collection and storage underneath slatted floors in the animal house is the most common management system.

Variability and nutrient content

One of the biggest problems with using slurry within a nutrient management plan is the substantial variability of dry matter (DM) and nutrient concentrations of slurries. Slurry composition will vary due to differences between animal types and diets. Variability can also be due to the dilution of slurry with water from dairy parlour washings, rainfall collected from open yards or open slurry stores, or the water added for flushing. Water, of course, dilutes both the solids and nutrients in the slurry and for this reason nutrient content is often correlated to the dry matter content.

The variation in slurries, even between two tanks on the farm, can be quite considerable. The nutrient concentration in slurry is often given a fixed average value in many extension documents and regulations. Examples of these average values from extension literature in Ireland and the United Kingdom (UK) are shown in Table 1. Using fixed values can reduce the flexibility required to manage slurry based on variable nutrient contents. A nutrient management plan using the actual nutrient content should be used in order to ensure that the nutrient resources in slurries produced on the farm are put to good use.

Laboratory analysis

While laboratory analysis is the most accurate way of assessing the dry matter and nutrient content of slurry, this is problematic for farmers. First, it is difficult to get a representative sample, especially when sample sizes need

Table 1. Examples of typical average nutrient concentrations in extension literature from Ireland and the UK.

	Slurry Type	DM %	Nutrient Content (kg/t)		
			N	*P*	*K*
Ireland (Coulter and Lalor, 2008)	*Cattle Slurry*	> 7	5.0	0.8	4.3
	Pig Slurry	4	4.2	0.8	2.2
UK (DEFRA, 2010)	*Cattle Slurry*	2	1.6	0.3	2.0
		6	2.6	0.5	2.7
		10	3.6	0.8	3.3
	Pig Slurry	2	3.0	0.4	1.7
		4	3.6	0.8	2.0
		6	4.4	1.1	2.3

to be small enough for postage or delivery to a laboratory. Second, farmers need to know the nutrient content on the day of application. Since the slurry will usually be agitated on the day of spreading, it is difficult to get a good sample in advance to adjust application rate decisions. Laboratory results will take a number of days or weeks to come back, which limits their value when making 'on-the-spot' decisions on application rates.

On-farm measurements

There are a number of on-farm measurement tools available that can be used for quick assessment of slurry characteristics. One of the simplest tools is the hydrometer (Fig. 1) which measures the specific gravity (density) of a liquid. There is a strong relationship between the density of slurry and the DM content (Tunney and Molloy 1975). The DM content of the slurry helps to estimate the total nitrogen (N), phosphorus (P) and potassium (K) concentrations.

Figure 1. A slurry hydrometer can be used to get a rapid estimate of the dry matter content of slurry. The deeper the hydrometer sinks, the more dilute (lower DM) the slurry.

The hydrometer indicates the density or DM of the slurry sample based on the depth to which it sinks when allowed to float in a sample; the deeper it sinks, the more dilute the slurry (Fig. 1). The hydrometer is cheap, quick and easy to use - but easy to break.

The relationship of DM to nutrient content is different for each nutrient. DM concentration predicts P very well since most P is contained in the solid component of the slurry. However, predicting N and K is less accurate since more of these nutrients are dissolved in the liquid fraction and hence less dependent on the DM concentration. However, the slurry hydrometer is a useful guide for all nutrients.

Fertilizer replacement value of slurry

The fertilizer value of slurry is usually described as the quantity of fertilizer that a slurry application can replace in meeting the crop requirements. Of course, slurry will have no value if applied in situations where the nutrients are either not required or are not available to a crop. Slurry application should always be in balance with complementary fertilizer applications in order to ensure that the crop has all its nutrient requirements met, without over-supplying any of the nutrients. Since N, P and K are the nutrients most commonly applied to crops, the slurry application should replace these fertilizers.

To maximize the fertilizer replacement value of manure, consider: Where to spread; When to spread; and How to spread.

1. Where to Spread? Maximizing the P and K potential in slurry.

While the N fertilizer value of cattle slurry is often emphasized, optimizing the P and K fertilizer potential of slurry is also important. The timing and method of application will have less effect on P and K than N fertilizer replacement value of slurry applied to grassland. The critical factor that will determine the potential of slurry to reduce fertilizer P and K costs will be the selection of fields for spreading on the farm.

The P and K requirements will vary among fields on a grassland farm. The requirement for each field or area will be determined by the field usage (grazing vs. silage vs. crops); enterprise (dairy vs. beef); the stocking rate; history of nutrient application and the soil test results. Knowledge of all of these factors is needed to determine where the P and K is required and to avoid over-supply of nutrients in some areas.

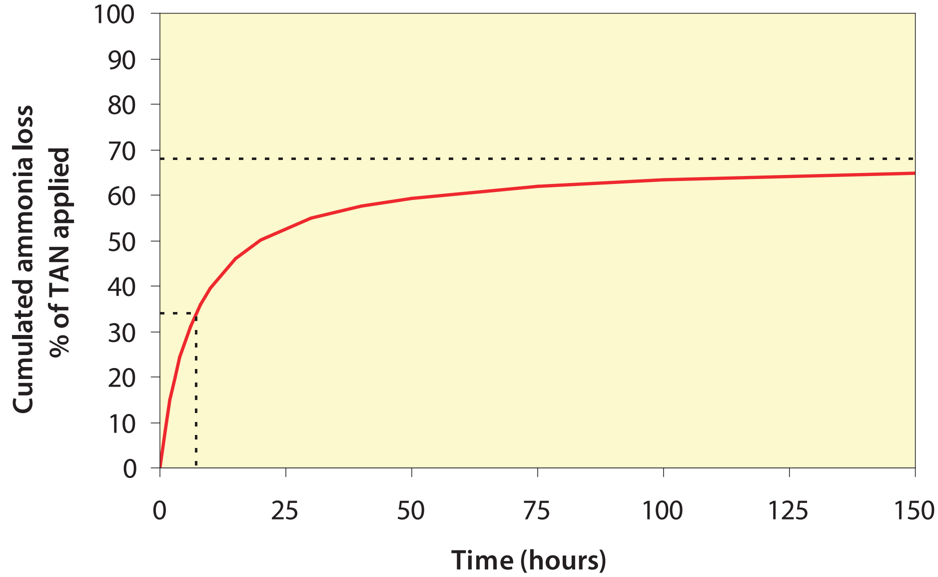


Figure 2. Typical ammonia emissions profile following surface application of slurry. Note that half of the emission losses ocur in the first 6 hours after application.

2. *When to Spread? Maximizing N fertilizer value*

The N fertilizer replacement value of slurry is highly dependent on the gaseous losses of ammonia that can occur following application. Ammonium-N in slurry is readily available for plant uptake; however, the ammonium-N in manure can be easily lost to the air by volatilization. This process lowers the N fertilizer replacement value of manure, and results in environmental issues regarding air quality. The process of volatilization occurs very quickly after application (Fig. 2). Total emissions of ammonia can be quite high, with up to 100% of ammonia potentially being lost depending on weather conditions, slurry DM content and application method. You can calculate potential ammonia losses from your slurry manure using the ammonia calculator on **www.farmwest.com.**

Timing application according to weather conditions

Ammonia emissions are highest under warm, dry, windy conditions (i.e. when evapo-transpiration rates are high). Emissions can be reduced by timing application when conditions are cool, humid and still (e.g. in the evenings), or before and during light rain, and by avoiding spreading during warm weather, intense sunlight and wind (e.g. June/July) (Reidy and Menzi 2007).

Planned application timing can be a cost-effective approach to reduce emissions, as it can be done even using broadcast slurry spreaders. An Application Timing Management System (ATMS) could assist in decision support to reduce ammonia losses and increase N fertilizer replacement value particularly in grassland where injection is problematic. The following principles may be included in an Application Timing Management System:

3) *Weather-determined variation in ammonia emissions.* Ammonia emissions tend to be lower in cool and wet conditions and after light rain (though water-logging of soils can make spreading conditions unfavourable and reduce infiltration of slurry). The timing of application in cooler and more humid conditions, or close to rainfall, reduces the potential ammonia emissions.
4) *Seasonal variation in ammonia emissions.* Ammonia emissions can be estimated on a seasonal basis by generalizing weather conditions for particular seasons. For example, seasonal variations lead to largest ammonia emissions in warm summer conditions and smaller emissions in cool, moist, but not frozen, winter conditions. Application in spring corresponding with the onset of grass growth is recommended in Ireland, and farmers are adopting this strategy over more traditionally popular summer application to increase the N fertilizer replacement value of slurry. However, other constraints, such as the objective to match manure application to the timing of crop needs, and the need to avoid water pollution, must also be considered when deciding on application timings.
5) *Diurnal variation in ammonia emissions.* Ammonia emissions tend to be smaller at night due to reduced air movement (windspeed), cooler temperatures and higher humidity. Applications between evening and early morning have been shown to reduce emissions by up to 50% compared with spreading during the middle of the day (Moal et al. 1995; Sommer and Olesen 2000).

6. *How to spread? Slurry application methods to reduce loss of ammonia on grassland*

Slurry application in most countries is usually carried out using splashplate (broadcast) spreaders. This applicator serves farmers well because: efficient work rates; simplicity of technology hence minimal machine downtime; and low purchase and maintenance cost. While the splashplate

Bandspreading

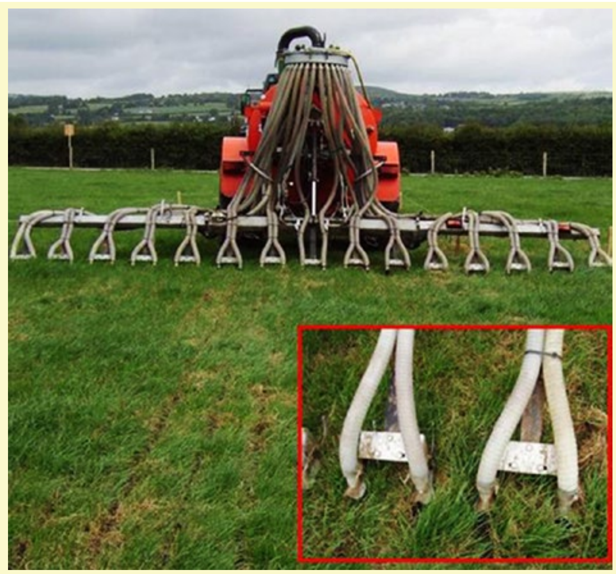
The bandspreader is the simplest low-emission method, and can be used in both grassland and arable crops. The slurry is deposited by pipes that are situated above the crop. While the ammonia losses compared to splashplate are reduced since the slurry is deposited in lines, some sward contamination will still occur since the slurry is applied above the crop canopy.

Trailing Hose

The trailing hose method is similar to the bandspreader in appearance and function, except that instead of the pipes depositing slurry above the canopy, they are longer and trail along the ground. This allows slurry to be applied directly at the soil surface. The trailing hose is commonly used for applying slurry in spring to winter cereal crops, as boom widths can be matched to tramlines to minimize traffic on the field (other than the tramlines).

Trailing Shoe / Sleigh Foot

The trailing shoe is a further adaptation of the bandspreader whereby each pipe has a 'shoe' coulter attached at the base of the pipe. The function of the shoe coulter is to separate the sward canopy and apply slurry at the soil surface. The advantage of this application method is that sward contamination compared to the splashplate is minimized, thereby facilitating application to taller grass swards with minimal effects on grass quality due to herbage contamination. Therefore, there is more opportunity for spring application to grassland.



Shallow Injection

The shallow injection method goes a step beyond the trailing shoe in that it has a disc that cuts a slit in the soil. The slurry is placed into this slit. This is the best method for reducing ammonia loss in grass, as the exposure of slurry to the weather is low. However, shallow injection may not be suitable to many soils due to the soil texture, stone content and topography. This method also requires greater tractor power to pull the injection unit through the soil. Application width and work rate are also reduced compared to the other application methods.

remains a popular application method, alternative methods of application for forage fields are becoming more available.

Low-emission application methods

The alternative application methods are collectively known as 'low-emission' methods, because they are designed to reduce the gaseous emissions of ammonia. The principle is that the slurry is applied in bands rather than broadcast over the entire area. By confining the slurry into bands, the surface area of slurry exposed to the atmosphere and sun, that cause ammonia loss, is reduced.

All low emission methods distribute slurry through a set of pipes via a rotary distribution manifold. In order to avoid blockages in the pipes (typically 40–50 mm or 1.5–2 in), a chopping system is normally required. This chopping system can either be included within the distribution manifold or can be fitted separately on the inlet of the tanker.

The four most common low-emission methods for grasslands are: bandspreading; trailing hose; trailing shoe/sleigh foot; and shallow injection. Deep injection systems are also available, but tend not to be recommended on perennial forage crops due to the high degree of sod disturbance. All low emission applicators reduce odour and improve precision relative to broadcasting.

Impact on N fertilizer replacement value

The reduction in ammonia emissions using low emission application methods is well researched, and reductions of 30–80% in ammonia losses following application with low emission application methods have been reported in many countries. In Ireland, research has also shown that this reduction in ammonia loss can result in an increase in the N fertilizer replacement value of slurry. Studies comparing the N fertilizer replacement value of cattle slurry applied to grassland in April and June with splashplate and trailing shoe showed that the trailing shoe method increased the N fertilizer replacement value by approximately 10%. The research also showed the N fertilizer replacement value benefits of applying slurry in April rather than June (Fig. 3).

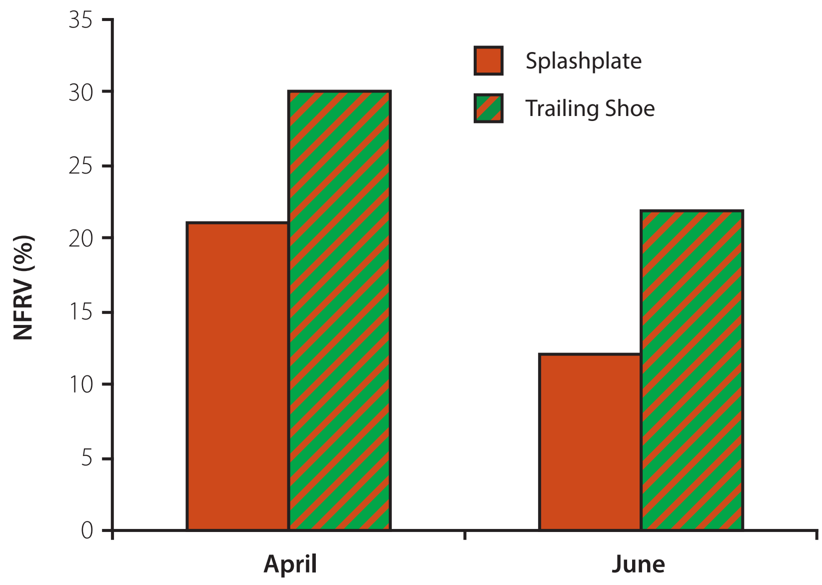


Figure 3. Effect of application method and timing on the N fertilizer replacement value (NFRV) of cattle slurry applied to grassland in Ireland (Lalor et al. 2011).

Reduced herbage contamination

One of the major issues with slurry application to grassland is the requirement to avoid herbage contamination that can affect subsequent herbage quality. This is particularly difficult with application in spring as there is often a cover of grass from winter growth and spring application may be delayed by poor soil drainage conditions and trafficability. Research in the United Kingdom has shown that low emission methods can allow slurry application into taller swards without negatively affecting silage quality or grazing preference (Laws and Pain 2002; Laws et al. 2002).

We modelled the extent to which both soil trafficability and herbage growth restrict spring application of slurry to grassland on contrasting soils in Ireland (Lalor and Schulte 2008). Our study showed that low emission applicators greatly increased availability of spreading opportunities in spring by allowing slurry to be spread into taller grass

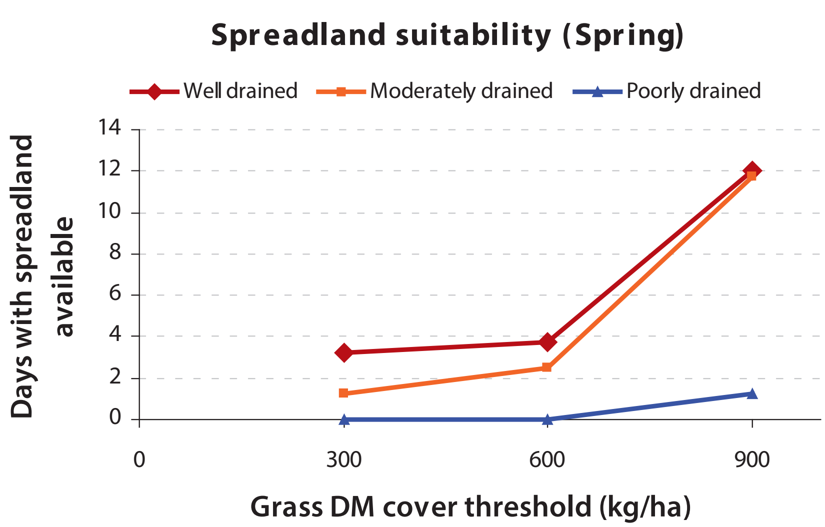


Figure 4. Effect of sward herbage mass threshold for slurry application on the number of days in spring available for slurry application (Lalor and Schulte 2008).

covers (Fig. 4). The effect was greatest on well and moderately well drained soils. We also showed that while soil trafficability is a major constraint on spreading opportunities, application methods that reduce soil compaction damage such as umbilical (tankless) application systems or reduced ground pressure tires will increase the opportunities for application and reduce soil compaction.

Should a farmer switch to a low emission applicator?

The costs and benefits of switching to a low emission spreader will need to be assessed on an individual basis. Any of the low emissions methods are more expensive to purchase than the splashplate, and are often more suited to larger tankers. For applications to grassland, the aim should be to apply as much slurry as possible in weather conditions that minimize the loss of ammonia. Where this can be achieved using the splashplate method, the further advantages to N utilization of using a low emission method can be small. However, splashplate use is often restricted by the risk of sward contamination so application is limited to very low grass heights. Contaminated grass should not be grazed or harvested for at least six weeks after application. By reducing grass contamination, low emission spreaders allow more manure to be spread in spring and less in summer thereby avoiding the conditions which favour ammonia emissions.

Other advantages of the low emission methods include a noticeable reduction in odour and more uniform manure application.

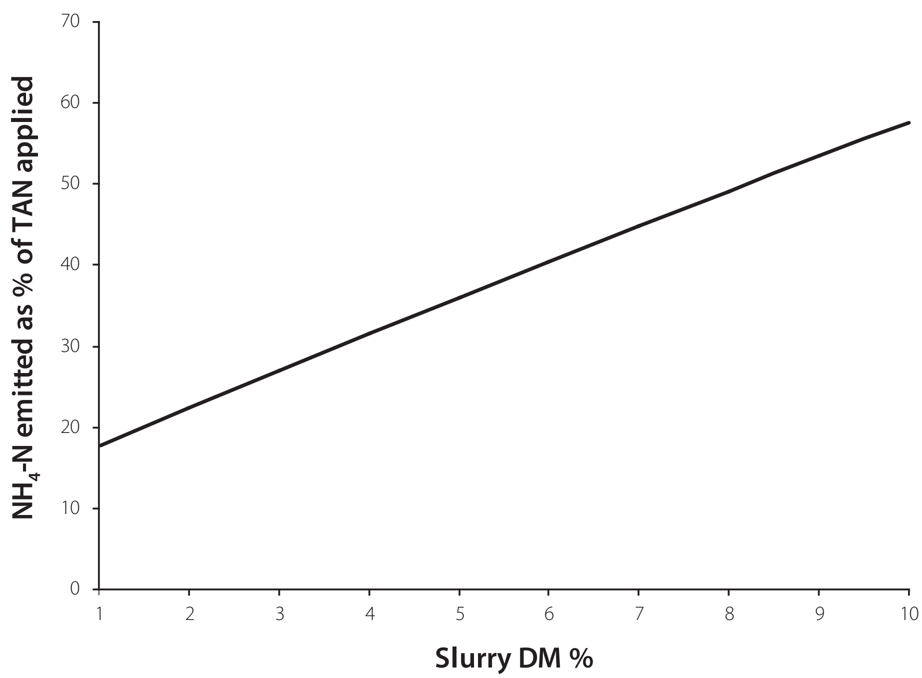


Figure 5. Ammonia emissions are reduced with lower DM slurries.

Ammonia loss and slurry dry matter content

Slurry DM can vary naturally due to animal type or diet, or it can be altered either by dilution with water or by mechanical separation. Low DM slurries can also occur as a result of rainwater addition over unroofed slurry stores or animal enclosures. Dirty water generated from washing animal handling facilities or milking parlours can also be classified as low DM slurry. A number of studies have shown a linear relationship between slurry DM content and ammonia emission after land spreading, with ammonia emissions decreasing 4–11% for every 1% decrease in slurry DM content (Fig. 5). However, it is important to note that dilute slurries will have lower nutrient concentrations, and hence require higher application volumes which add greatly to cost of application.

Conclusion

Slurry is a valuable source of nutrients for offsetting fertilizer costs in forage systems.

- Slurries are variable and farmers should try to establish the nutrient content of their slurry. On-farm tests such as the hydrometer can be quick and useful guides.
- Decide where to apply slurry based on P and K requirements.
- Decide when and how to spread slurry based on reducing ammonia losses and increasing the N fertilizer replacement value.
- Timing application in cooler, moister conditions can be a low-cost way of reducing losses and increasing N fertilizer replacement value.
- Low emission spreaders also increase N fertilizer replacement value, and can also provide benefits of reduced sward contamination and increased opportunities for application.
- Slurries with lower DM have reduced losses of ammonia. However, nutrient content of dilute slurries can also be low.

References available online at www.farmwest.com

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