Economic costs and benefits of adoption of the trailing shoe slurry application method on grassland farms in Ireland

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Introduction

The emphasis on maximising the nitrogen fertilizer replacement value (NFRV) of cattle slurry has been revived in Ireland in recent years for a number of reasons, including:

(i) Nitrogen (N) fertilizer prices have increased by approximately 100% in the last five years.
(ii) Legislative restrictions have been introduced that control the quantities of fertilizers that can be applied to crops. This legislation also specifies the NFRV that must be assumed for slurry applications (Anon, 2006).
(iii) Approximately 30% of ammonia emissions from Irish agriculture is attributable to landspreading of cattle slurry (Hyde *et al.*, 2003). While Ireland is currently compliant with its ammonia emission target for 2010, the requirement to comply with future targets for reduced ammonia emissions may affect future slurry management practices.

Slurry application method, and in particular its effect on slurry placement, is considered a key determinant of the NFRV of slurry (Schröder, 2005). Application methods that reduce gaseous losses of N as ammonia have the potential to increase the NFRV of slurry, since the N not lost to the atmosphere may be utilised by the crop.

At present in Ireland, almost all cattle slurry application to grassland is performed using the splashplate (broadcast) method. The most common timing of slurry application is after first cut silage (May to July), accounting for 48% of the total slurry applied, with 34% applied in spring (February to April), and the remainder in the autumn period (Hyde and Carton, 2005).

The environmental benefits of low-emission slurry application methods such as band spreading, trailing shoe, and injection, for reducing the gaseous emissions of ammonia from landspreading of animal slurries are well established. However, the implementation of these technologies is often limited by the increased purchase and running costs associated with this machinery compared with the splashplate application method. In some European countries, this obstacle to technology adoption has been overcome by enforcing legislation. Since such legislation is not in place in Ireland, high rates of adoption will be dependant on measurable economic advantages to individual farmers.

Potential for low emission application methods in Ireland

Of the low-emission application methods available, the trailing shoe method is considered to be the most suitable for Irish grassland. It minimises the grass contamination observed with band spreading and splashplate application, and also avoids potential problems with slurry injection in Irish soils due to variability in stone content, texture, drainage and topography. Results from Irish research show a reduction in ammonia emissions of 28% with trailing shoe compared to broadcast applications (Dowling *et al.*, 2008). However, the resulting increase in nitrogen fertiliser replacement value can be low (Lalor and Schulte, 2007). Therefore the potential savings on fertilizer nitrogen costs based on application method alone are relatively small in an Irish context.

Current agronomic advice in Ireland assumes that larger savings on fertilizer nitrogen can be made by applying slurry to grassland in the spring (February to April) period, rather than in the summer (June and July). The NFRV of slurry applied with splashplate in summer is assumed to be 5%, whereas the NFRV increases to 25% for spring application (Coulter, 2004). Nutrient advice in the UK also assumes a higher NFRV for spring application (35%) compared to summer (20%) (DEFRA, 2006).

The main restriction to splashplate application in spring is the requirement for suitable soil trafficability conditions to coincide with short grass covers so that herbage contamination can be minimised. The trailing shoe method minimises grass contamination by applying slurry in lines below the grass canopy. Therefore, it allows greater flexibility of application timing by facilitating application on taller swards (Laws *et al.*, 2002). This results in more spreadland being available for slurry application on the days in spring when weather conditions allow traffic. There is potential for greater savings on fertiliser N costs through adoption of the trailing shoe technology, as a greater proportion of slurry may be applied in the spring when the nitrogen fertilizer replacement value can be maximised (Lalor and Schulte, 2008).

The objective of this study was to evaluate the economic implications of adopting the trailing shoe technology, both in terms of costs, and benefits to the farmer. The potential benefits of the trailing shoe by way of increased flexibility of application timing in addition to the ammonia emission reductions were evaluated.

Economic costs

The main economic barrier associated with the adoption of the trailing shoe technology on grassland farms is the increased purchase and operational costs compared to the splashplate. The costs per hour and per m^3 of slurry applied for trailing shoe and splashplate are estimated in table 1.

Table 1. Comparison of costs associated with splashplate and trailing shoe slurry application methods. (Lenehan, J.J. and Ryan, T., *pers. comm.*)

Fixed costs	Splashplate		Trailing Shoe	
	75kW tractor	Splashplate	90kW tractor	Trailing shoe
	€	€	€	€
Cost Price (initial cost)	50,000	15,000	65,000	40,000
Trade-in Value	20,000	5,000	20,000	12,000
Depreciation	3,750	2,000	5,625	5,600
Interest	1,962	609	2,551	1,625
Insurance, tax	1,000	-	1,000	-
Total annual cost	6712	2609	9176	7225
Tractor cost/hr. (@1,400 hr/yr.)	4.79		6.55	
Application method cost/hr. (@400 hr/yr.)		6.52		18.06
Total cost/hr		11.32		24.62
Operational costs (per hour)		€/hr		€/hr
Fixed costs/hr.		11.32		24.62
Fuel/grease cost/hr.		4.00		4.00
Repairs/maintenance cost/hr.		2.96		5.46
Labour cost/hr.		15.00		15.00
Overhead costs (10% machine costs)		1.13		2.46
Cost €/hr.		34.41		51.54
Charge for 20% of time at transport		6.88		10.31
Cost €/hr.		41.29		61.85
Profit margin (12.5%)		5.16		7.73
Charge rate/hr. (VAT excluded)		46.45		69.58
Cost per m^3 slurry applied		€/m^3		€/m^3
Cost €/m^3 (rate = 30m^3/hr)		1.55		2.32

The following assumptions were made in deriving the cost comparisons shown in table 1:

- Application machinery purchase prices were based on current estimates for a vacuum tanker with an approximate capacity of $10m^3$.
- Application costs assume that slurry is applied by contractors, rather than with farmer-owned machinery.
- The costings include both tractor running costs, and application machinery costs. It was assumed that the trailing shoe will have a higher draught requirement than the splashplate equipment, and the power rating and purchase cost of the tractor was increased accordingly.
- Depreciation costs were calculated as the difference between the purchase price and the trade-in value, divided by the number of years for which the machine is kept. It was assumed that the replacement age of the tractor is eight years, and the replacement age of the splashplate and trailing shoe are five years.
- Interest rates were assumed at 6.5%.
- Tractor work per year = 1400 hours
- Slurry equipment work per year = 400 hours
- Average work rate = $30m^3$ slurry applied per hour. Work rates were assumed equal for both application methods.

The trailing shoe application method was more expensive by €23.13/hour, (or €0.77/m^3) than the splashplate method. While the higher overhead, tractor and repairs/maintenance costs contribute in part to this increase, the higher interest and depreciation costs associated with increased purchase price of trailing shoe is the main source of the increased cost.

Another economic barrier that may also restrict the adoption of trailing shoe is the effect of the increased weight of the trailing shoe attachment on soil compaction. Typical trailing shoe attachments available in Ireland add an additional weight of 750 to 1500 kg to the machine. Avoidance of compaction needs to be a key consideration when deciding tyre specifications for trailing shoe machinery, especially since an important benefit of the system is the increased facilitation of slurry application in spring, when soil trafficability conditions are often wetter more susceptible to damage from compaction than in summer.

Economic benefits

There are a number of possible ways that the trailing shoe may add value to slurry as an alternative to the splashplate. For example, the reduction in odours associated with the trailing shoe is of particular value to individual farmers, particularly in areas adjacent to towns or villages where odours from slurry application are often viewed as problematic. The reduction of ammonia emissions is also of benefit to society generally through improved air quality. However, while such benefits may be of particular value to an individual, they are difficult to evaluate in terms of economic benefits that will justify increased costs to the farmer.

The main quantifiable benefit regarding slurry value to the farmer will be the effect on the fertiliser replacement of the slurry. Application method will have no effect on the phosphorus and potassium fertilizer replacement value of slurry. However, the effect of the trailing shoe on reduced ammonia emissions compared with splashplate should increase the NFRV of slurry.

Estimates of the economic value of slurry applied with splashplate and trailing shoe in both summer and spring are shown in table 2. The typical total N and ammonium-N contents in cattle slurry in Ireland are estimated to be 3.6 and 1.8 kg/m^3 respectively. The assumption made in Irish nutrient advice of 5% and 25% NFRV of slurry in summer and spring respectively (Coulter, 2004), equates to ammonia emissions with splashplate of 90% in summer, and 50% in spring.

Dowling *et al.* (2008) observed, under Irish conditions, a decrease in ammonia emission of 28% with trailing shoe compared to splashplate. These levels of emissions were the average emissions observed from five application dates between late April and late July. Emissions were affected by application timing and, in particular, solar radiation levels after application. The lowest emissions were observed on the April application date. A 28% reduction in ammonia emissions with trailing shoe compared with splashplate would correspond to ammonia emissions of 65% and 36% in summer and spring respectively with trailing shoe.

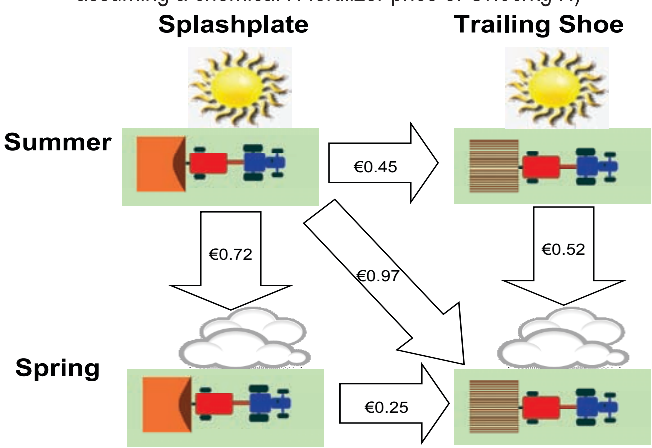
It is assumed in these calculations each 1 kg of the ammonium-N not volatilised will be utilised by the crop to substitute 1 kg of chemical N fertilizer.(since N losses via nitrate leaching and N_2O/N_2 emissions will be minimal).

Table 2. Comparison of the economic value of the N fertiliser replacement potential of cattle slurry applied to grassland with the splashplate and trailing shoe application methods with spring and summer application timings. (Value of slurry N is calculated assuming a chemical N fertilizer price of €1.00/kg N)

Method		Splashplate		Trailing Shoe	
Timing		Summer	Spring	Summer	Spring
Slurry	Total N content (kg/m^3)	3.6	3.6	3.6	3.6
	NH_4-N content (kg/m^3)	1.8	1.8	1.8	1.8
NFRV %		5%	25%		
% Ammonia emissions		90%	50%	65%	36%
Ammonia-N emissions (kg/m^3)		1.62	0.90	1.17	0.65
Crop available N (kg/m^3)		0.18	0.90	0.63	1.15
Value of N (€/m^3)		€ 0.18	€ 0.90	€ 0.63	€ 1.15

The economic benefits through potential savings in fertilizer N are greater with changing application timing than with changing application method (figure 2). The benefit of switching application with splashplate from summer to spring is valued at €0.72/m^3. If application timing is constant, then changing the application method from splashplate to trailing shoe will increase the value of slurry by €0.45 in summer, and €0.25 in spring. The largest increase in slurry value (€0.97/m^3) is achieved when trailing shoe adoption is combined with a change in application timing.

Figure 1. Effect of a change of application method and/or application timing on the change in economic value per m^3 of cattle slurry applied to grassland. (Value of slurry N is calculated assuming a chemical N fertilizer price of €1.00/kg N)



Discussion

The principle economic cost of the adoption of the trailing shoe method for slurry application to Irish grassland is the purchase cost of the equipment. In the absence of legislative restrictions on slurry application methods, any large-scale adoption of the trailing shoe technology will require an economic return for the increased costs incurred. With an increased cost of €0.77/m^3 associated with trailing shoe application as an alternative to splashplate, slurry applied with the trailing shoe would need to be worth at least that much more to the farmer than it would have been were it applied with the splashplate.

The least cost option for farmers to increase the NFRV of slurry is to apply in spring with existing splashplate technology. Where this can be achieved, the extra cost of adopting trailing shoe technology will not be recovered through additional fertilizer N savings. However, spring application with splashplate is often restricted due to sward contamination.

The principle economic benefit of the trailing shoe method is the potential to reduce chemical fertilizer N inputs by improving the NFRV of slurry. However, the potential fertilizer cost savings from only changing application method are not sufficient to recover the increased cost of the technology. It is only the combination of reduced ammonia emissions and improved opportunity for spring application that make the trailing shoe technology economically justifiable to farmers through savings on fertilizer nitrogen.

This economic analysis is subject to changes in the underlying assumptions. For example, increased fertilizer N prices would result in an increased economic value of the savings in fertilizer N through reduced ammonia emissions with trailing shoe.

A reduction in the purchase price of the trailing shoe through government grant aid would decrease the adoption costs. In recent years, grant aid, from the Department of Agriculture, Fisheries and Food, has been available to Irish farmers who purchase trailing shoe equipment, at a rate of 40% of the purchase cost. Based on these costings, such a grant would have an effect of reducing the overall cost per hour for trailing shoe to €55.28/hour, or €1.84/m^3. However, this grant aid was specifically targeted towards farmers and was often unavailable to agricultural contractors as a result. It has also been recently terminated.

While cost reductions may be possible through, for example, improved work output per hour, or by reducing overhead costs, such improvements are equally applicable to both application methods. This further highlights the importance of the difference between the purchase price of each application method as the driver of eventual cost to the farmer, and resultant technology adoption.

Many farmers in Ireland have their own application machinery. In such cases, the spreading costs per m^3 slurry may increase since the purchase costs of the tanker are divided over a lower volume of slurry.

Further analysis is required to evaluate alternative options for increasing the application of slurry in spring. While grass contamination is one limitation to spring application with splashplate, soil trafficability is also a key consideration (Lalor and Schulte, 2008). The trailing shoe method needs to be considered relative to other application options, such as the umbilical system, which can apply slurry with reduced soil compaction effects.

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