A management perspective on improved precision manure and slurry application

Une perspective de gestion pour améliorer la précision de l'épandage de lisiers et fumiers.

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Abstract

Surface application of manures and slurries is still, by far, the most common approach used on UK farms for the spreading of farmyard manure (FYM), poultry manure (PM) and slurries. On-farm evaluation of spreading machinery performance has been undertaken, including a total of 41 separate machines, covering the four main machine categories currently in operation and three manure types :

- *side discharge, rotary spreaders (FYM)*
- *vacuum tankers (slurry)*
- *side discharge, dual-purpose spreaders (FYM, PM, slurry)*
- *flat-bed, rear discharge spreaders (FYM, PM).*

Whilst substantial variaiblity in machine performance (both in terms of application rate and spreading pattern) was observed, date on lateral coefficient of variation(CV) and spreading bout width indicated that considerable improvements in performance could be achieved by simple adjustment of bout spacing.

Keywords : organic manures, land application, precision, management

Résumé

L'épandage en surface des fumiers et lisiers est à ce jour la pratique la plus courante au Royaume-Uni. Des essais à la ferme en utilisant le matériel d'épandage ont été réalisés, soit un total de 41 équipements testés couvrant les 4 catégories suivantes :

- épandeur latéral rotatif (fumiers)
- tonnes sous vide (lisiers)
- épandeur latéral

Bien qu'une grande variabilité dans les performances des équipements testés ait été observée, des améliorations considérables peuvent être obtenues avec de simples ajustements.

Mots-clés : déjections, épandage, précision, gestion.

1. Introduction

In arable, mixed farming, and predominantly grassland areas of the UK, it is common practice to apply livestock manures, including slurries and solid manures, to land during the autumn and early winter period. Manure stores and slurry tanks are often emptied prior to the winter when the accessibility of arable stubbles and trafficability of land make this the ideal time for spreading operations. The perceived usefulness of manure nitrogen (N) is low, because of the losses anticipated over the winter months; also, because the focus is not on the utilisation of manure nutrients, little attention is paid to way in which spreading operations are carried out.

Poor (uneven) manure applications may cause problems due to nutrient excess (e.g. crop lodging in cereals, excessive top growth in root crops and poor quality), or nutrient shortage and possible yield reduction. In a recent study of manure management practice on farms in England and Wales, a high proportion of farmers (>75% with poultry manure, >60% with pig manure) agreed that if they could apply manures more evenly, they would consider spring application and further savings on fertiliser inputs (Parham, 1997). Moreover, as guidelines on the utilisation of manures improve (e.g. Steffens and Lorenz, 1997; Chambers *et al*, 1996) and farmers attempt to reduce fertiliser inputs, the accuracy and reliability of manure spreading increases in importance.

The studies described in this paper have focused on the range of manure spreader performance achieved on commercial farms, the importance of accurate spreading for grass silage production and on some preliminary strategies for improved spreading practice.

2. Approaches

On-farm manure spreader tests

On-farm tests were carried out on a range of machinery, working under normal operating conditions, i.e. with no attempt to influence the operator. The principal performance criteria assessed during this study were as follows :

(1) *Bout matching* (to determine overlapping of adjacent runs) - the distance between a reference marker, such as a nominated wheel, was recorded manually, at a minimum of seven points spaced at 25 metre intervals along the line of travel, on adjacent runs.
(2) *Forward speed* - assessed by the accurate measure of time taken for travel between markers at 25 metre intervals.
(3) *Lateral uniformity* - methodology was based on spreader evaluation procedures proposed by the European Committee for Standardisation (CEN, 1996), using plastic trays 0.5m x 0.5m and 100mm deep, laid in a line perpendicular to the direction of machine travel and to at least 8m to either side of the centre line. For spreader types discharging to one side only, collection trays were laid out

accordingly. From the recorded tray weights, lapped and unlapped spreading patterns, and associated Coefficient of Variation (CoV) were computed.
(4) *Discharge rate over run duration* was assessed by static test, with weight of the machine recorded at 6 second intervals during discharge from fully laden. In this paper only results of bout width and lateral spread uniformity are presented.

Agronomic effects of spread pattern on grass for silage

Replicated grassland plot experiments, to evaluate the agronomic effects of slurry distribution pattern, were undertaken before first or second silage cuts over two years. Cattle slurry was applied to strips 1.5m wide and 5m length, using a plot applicator (Basford et al, 1996), at varying rates over 7 such strips making up a full plot size of 10.5m x 5m. Application rates, over the full plot, were set at 40m^3/ha but were achieved with varying levels of lateral uniformity (0%, 17%, 32% and 41% CoV), according to distribution patterns typical of those observed in the on-farm tests. The effects of the slurry N, at the rate applied (approx. 80 kg/ha total N, 39 - 46 kg/ha NH_4-N) and an extra 40 kg/ha fertiliser N were compared with grass N response, based on 6 levels of N (0-180 kg/ha).

Improved spreader performance testing

Further tests on a limited number of machine types and focusing on specific factors likely to affect performance, including manure type and consistency, machine settings, slurry splash plate design and setting, have also been undertaken but are not reported here.

3. Results and discussion

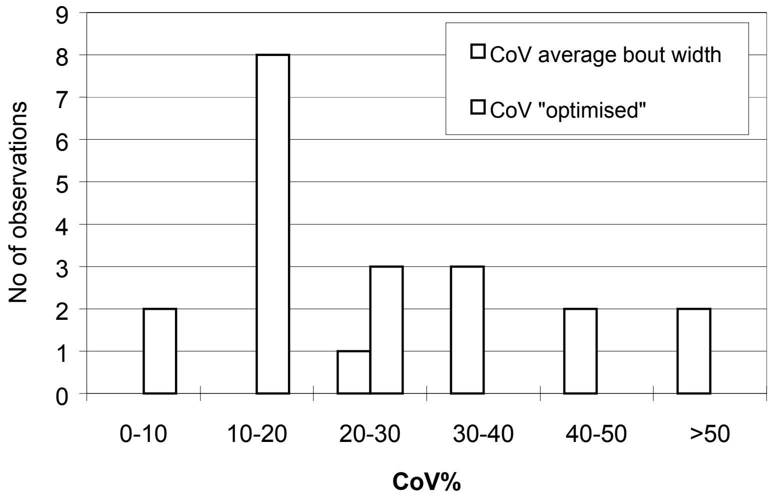
On-farm manure spreader tests

A total of 41 separate machines have been tested, covering four main categories:-
- side discharge, rotary spreaders (FYM)
- vacuum tankers (slurry)
- side discharge, dual-purpose spreaders (FYM, PM, slurry)
- flat-bed, rear discharge spreaders (FYM, PM)

Together, these machines are representative of the great majority of spreading equipment currently in use within UK farming. Application rates were highly variable between farms and spreaders, and from the spreaders themselves, even where machine make and type was similar, and also over the run duration of a single machine. One disappointing feature of the study was that, in many cases, it was apparent that farmers had little knowledge of the nutrient content of the manure being spread or of the capacity of the spreader and, therefore, application rate.

Lateral CoV, measured at the average bout width for each machine, could be greatly reduced, simply by adjusting bout width according to computer simulation to estimate the optimised, lapped spread; the results of this procedure are summarised initially in figure 1(a) for slurry tankers and (b) across the 3 types of solids spreaders. In all cases, lateral CoV could be reduced to less than 30%, with the majority below 20%, as a result of initial testing and optimum setting of spreader bout width. Adjustment for optimum spread pattern, in general, required a reduction in bout width (see Table 1), though for individual machines, especially slurry tankers, this was not always the case. On grassland, such adjustments to spreader bout width would cause no difficulty, in contrast to manure top dressing of arable crops where tramline systems of up to 24m would render such adjustments almost impossible, except for the adoption of new technology, low trajectory slurry applicators of the type now in common use in the Netherlands, Germany and Denmark.

(a) Slurry vacuum tankers (13 observations)



(b) Solids spreaders (26 observations)

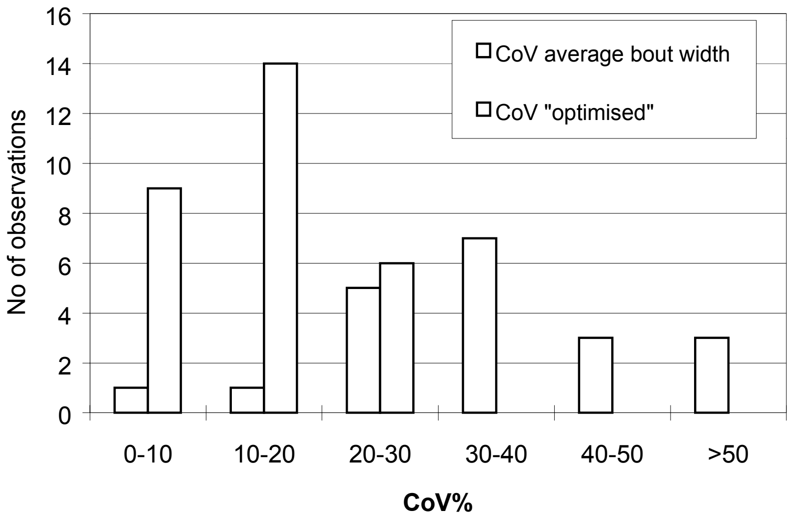


Figure 1.
Frequency distribution of lateral CVs measured at average bout width compared to calculated CV at optimum bout width

Machine Type	No of Observations	Recorded Performance		'Optimised' Performance	
		Av. bout width (m)	Ave CoV%	Opt bout width (m)	Opt CoV%
Rotary	9	3.5	39	2.3	15
Slurry tanker	14	8.9	37	9.1	15
Rear-discharge	6	4.4	22	3.5	11
Dual-purpose	12	6.0	35	4.3	20

Table 1.
Average observed machine bout width and CoV and comparison with simulated optimum bout width and CoV.

Agronomic effects of spread pattern on grass for silage

Despite a clear response to fertiliser N, up to 70-80 kg/ha N in the second cut in 1996 and, up to 100-120 kg/ha N, first cut 1997, there were no significant differences between spread patterns, either in terms of dry matter (DM) yield or N offtake. However, significant increases in yield ($p < 0.05$) and N offtake ($p < 0.01$) were recorded from the extra 40 kg/ha N fertiliser, in both years, confirming the responsiveness of the site to N and the sensitivity of the experiment to potential yield loss and changes in grass N offtake, as a result of slurry spreading pattern (Table 2).

	Supplementary	Slurry distribution pattern CoV	

	fertiliser N	0%	17%	32%	41%	*p*	SED
2nd cut 1996							
DM yield t/ha	-	4.50	4.42	4.66	4.51	0.65	n.s.
	40 kg/ha	4.90	4.99	5.22	5.01	0.05	0.11
N offtake kg/ha	-	60.7	62.8	63.4	64.8	0.75	n.s.
	40 kg/ha	81.5	73.5	78.8	75.3	<0.01	0.96
1st cut 1997							
DM yield t/ha	-	5.88	6.20	6.40	5.85	0.39	n.s.
	40 kg/ha	6.97	7.00	6.85	6.94	<0.05	0.15
N offtake kg/ha	-	73.3	71.2	74.0	64.1	0.21	n.s.
	40 kg/ha	82.8	89.6	91.8	84.8	<0.01	0.96

Table 2.
Effect of slurry distribution precision, with and without fertiliser N top dressing, on grass DM yield and N offtake (1996-1997).

This result is not surprising, given that the overall, slurry application rate supplied 39 and 46 kg/ha NH_4-N, respectively, in the experiments in 1996 and 1997, i.e. well within the linear or steep part of the N response curve. Variation in N supply, as a result of variable slurry application, would inevitably result in localised increase or decrease in grass DM yield and N offtake, depending upon whether the slurry applied at that point was above or below target rate. Increased and decreased growth and N uptake, from areas of high and low N supply, respectively, then appear to have cancelled each other out, with a net result of no observable difference between the different spread patterns. Whilst such a result seems less likely following manure applications to arable crops sensitive to N supply, such as winter wheat or potatoes, it is quite common for N to be applied to grassland at sub-optimal levels and for dilute cattle slurry, with moderate N content, to be applied at rates of around 40 m^3/ha; Chambers *et al*, (1996) reported average N use on grass for silage, in England and Wales, 1992-1994, at 170 - 180 kg/ha, whereas the recommended rate for a two-cut system would vary 220 - 270 kg/ha, depending upon cutting date and residual soil N fertility (MAFF, 1994). Therefore, the results reported may be representative of many situations where manures are applied within grassland systems. In such situations, the sometimes quoted performance target of 16% CoV, as applied to the calibration of mineral fertiliser spreaders (Anon, 1984) seems unnecessarily ambitious.

4. Conclusions

4.1. On-farm assessments of manure spreading operations have confirmed that performance varies considerably between farms and, even, within a single machine type used under different conditions. In these studies, a lack of awareness was apparent, in many cases, of even some of the very basic requirements for good management of land spreading, such as the capacity of the spreader and the nutrient content of the materials being spread.

4.2. The lateral spread pattern CoV could be considerably reduced, by correct setting of machine bout width - typically a reduction in CoV of 50% or more was possible in this way, in most of the machines tested. Rear-discharge solids spreaders and slurry tankers with splashplates offer a symmetrical discharge pattern which facilitates successful bout matching and an overall low lateral CoV.

4.3. From agronomic assessments on the effect of manure and slurry spread pattern suggest that, where slurry or manure and fertilisers supply N at sub-optimal levels on grassland, application precision is not of critical importance. Taken together with the machinery tests, this work suggests that the currently available equipment, correctly set up and carefully managed, is capable of achieving very satisfactory results on many farms.

5. Acknowledgement

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