Effects of mechanically separated dairy cow slurry on grazing performance

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Abstract

Inorganic fertilisers are widely used to fertilise grasslands in dairy systems. Increasing the nutrient use efficiency of slurry applied as an alternative or supplementary fertiliser could reduce the volume of purchased fertiliser. This would reduce costs and improve security of future fertiliser supply since slurry is produced on farm. Slurry separation could increase the potential for fertilising grazed grassland with slurry. This experiment compared the effects on milk yields of fertilising grazing swards with the liquid fraction of separated slurry, whole slurry or inorganic fertiliser. Three groups of 12 core cows were grazed for two 24 day rotations on 2 day paddocks between 18 and 24 days after fertiliser treatment application in a put and take design. Nutrient use efficiency was significantly higher (*$P<0.05$)* from the liquid fraction of separated slurry (12.2 kg kgN^{-1}) compared to whole slurry (8.0 kg kgN^{-1}) application. This effect was most likely due to a combination of improved soil infiltration and reduced sward contamination.

Keywords: slurry separation, grazing, dairy

Introduction

Increasing yields from grazed grasslands using sustainably sourced fertilisers represents a major opportunity if we are to sustainably maintain or even increase levels of food production. Currently, slurry can be applied to grazed grasslands as a fertiliser, increasing the availability of essential plant nutrients (e.g. nitrates and ammonium) in the rhizosphere. However, inorganic fertilisers continue to be applied by farmers, since slurry contains a high proportion of dry organic matter which becomes assimilated into soils more slowly than inorganic fertilisers, resulting in lower grass yields (Møller *et al.*, 2000). Separation of slurry into the liquid fraction prior to application may therefore benefit farmers by reducing dry matter (DM) content, increasing rates of soil infiltration hence increasing herbage yields due to greater concentrations of nutrients being available to grass roots in solution (Møller *et al.*, 2000). Reducing the DM content may also enhance the potential for using slurry on grazing ground due to the lower sward contamination of more liquid slurries (Rodhe, 2003) reducing the risk of sward rejection by grazing cattle. This is of interest given that cattle grazing performance can be adversely affected by slurry applications on grazing pasture (Gjestang *et al*., 1984). Previous research investigating the use of slurry on grazing ground has shown that applying slurry by shallow injection can improve the resultant grazing performance relative to splash plate application (Laws *et al.* 1996). Likewise, Dale *et al*. (2012) showed that inorganic fertiliser inputs can be reduced by replacing a portion with cattle slurry applied by trailing shoe without adversely affecting dairy cow performance. This experiment compared the effects of applying separated slurry or unseparated slurry (without the addition of inorganic fertiliser) or inorganic fertilisers on grass yields, milk yields and nutrient use efficiency.

Materials and methods

The experiment was conducted during the summer of 2013 at the SRUC Dairy Research Centre, Dumfries, Scotland (NX 981 732). Three 1 ha paddocks were established in each of four fields. Two of the fields were dominated by Perennial ryegrass (*Lolium perenne*) and two were dominated by Italian ryegrass (*Lolium multiflorum*) (approx. coverage of dominant species greater than 95%). Each paddock in each field was then allocated one of three fertiliser treatments: whole (unseparated) slurry (W), liquid fraction of separated slurry (L) and ammonium nitrate fertiliser (F). Each treatment paddock was further subdivided into three 0.33 ha sub-paddocks with the aim of each sub-paddock providing two days grazing for twelve cows (with a herbage allowance of 15 kgDM cowday^{-1}). All fields were cut for silage in late May. Fields 1-3 were grazed initially on the silage aftermath and Field 4 was cut and baled before grazing. Dairy cow slurry was separated using a Sperrin dual cylinder separator and applied using a dribble bar approach at 24 m^3 ha^{-1} (liquid) and 27.5 m^3 ha^{-1} (whole). The different slurry rates, and an ammonium nitrate control, were calculated so that equal concentrations of available N (NO_2^- + NO_3^- + NH_4^+) were added to each treatment, according to standard values (Defra, 2010). Three groups of twelve mid to late lactation dairy cows were grazed on the treated pasture for two 24 day rotations, under a three times a day milking regime, with 0.5 kg cow^{-1} of concentrates being fed at each milking. Additional cows of a similar yield and weight were added to the groups when required to provide a target herbage availability of 15 kgDM cowday^{-1}. Statistical analysis were carried out using R i386 3.0.2 (R Core Team, 2013). Differences between the composition of W, L and F were tested using student’s t-tests. Treatment differences for herbage yield, milk yield and nitrogen use efficiency (yield / available N) were tested using Analysis of Variance tests (ANOVA) and Tukey’s Honestly Significant Difference (HSD) tests.

Results and discussion

Slurry separation decreased the mean DM of the slurry from 52±0.8 g kg^{-1} for W to 28±0.3 g kg^{-1} for L *($P<0.001$)*, but also reduced the mean concentration of available N from 1.3±0.02 g kg^{-1} to 1.1±0.01 g kg^{-1}, respectively *($P<0.001$)*, contradicting the standard values used to calculate the application rates (1.2 g kg^{-1} for W and 1.5 g kg^{-1} for L). L was therefore applied at a lower total rate over the experiment and had a lower concentration of available N, resulting in available N application rates of 68.9, 50.2 and 71.8 kg ha^{-1} for W, L and F, respectively. The stocking densities were 36.4±1.6 LU ha^{-1} for W, 36.4±1.4 for L and 45.8±1.8 LU ha^{-1} for F *($P<0.001$)*, showing that more grass was grown by F even though it was balanced with W and L by available N.

Daily milk yields were not affected by treatment at the cow or area (stocking density x yield) level *($P>0.05$)*. This suggests that grazing has not been adversely affected by using slurry as a fertiliser, regardless of whether it has been separated or not. However, the nutrient use efficiency (yield / available N applied) was significantly affected by treatment (Table 1). For every kg of available N applied, L produced 52 % more milk than W. Greater productivity is most likely due to improved soil infiltration resulting in a greater concentration of nutrients available to roots in solution for L than W coupled with lower sward contamination for L than W, in line with the findings of Rodhe (2003). The lower rate of available N application for L than W may account for some of the increase in efficiency, due to the non-linearity of N response curves. However, had the available N been equal between the treatments and the increased efficiency remained, there may have been a significant effect of separation on milk yield at the area level.

Conclusions

The L treatment increased nutrient use efficiency relative to W. This may be due to higher nutrient availability from L than W due to increased soil infiltration and smaller particle size. However, care needs to be taken in extrapolating these results since L was applied at a lower rate. Daily milk yield per cow was not affected by treatment, hence grazing performance does not appear to have been reduced by using either separated or whole slurry as a fertiliser relative to inorganic fertiliser. The results demonstrate the potential for growing grass for grazing from slurry alone, and suggest that separation may have a place in certain systems although more work is required to establish the economic implications.

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Table 1. Mean daily milk and fat and protein yields.

	W		L		F		Sign.
	Mean	s.e.	Mean	s.e.	Mean	s.e.	
Daily milk yield (kg cow^{-1})	15.1	0.2	16.8	1.0	16.0	1.5	NS
Daily fat + protein yield (kg cow^{-1})	1.14	0.02	1.19	0.07	1.13	0.10	NS
Daily milk yield by area (kg ha^{-1})	550	8	612	35	733	66	NS
Daily milk yield by available N (kg kgN^{-1})	8.0^{a}	0.1	12.2^{b}	0.7	10.2^{ab}	0.9	*

NS, not significant, *P<0.05.