The effect of application method and timing of application on slurry $^{15}NH_4$-N recovery in herbage and soil

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Introduction In Ireland, the implementation of the EU Nitrates Directive imposes strict limits to nutrient inputs onto livestock farms, placing renewed emphasis on improving manure nutrient recovery. Low-emission slurry application techniques such as shallow injection and trailing shoe have been shown to reduce ammonia emissions compared to broadcast by 73 and 57%, respectively (Misselbrook *et al.*, 2002). For Irish grasslands, the trailing shoe appears to be the most suitable alternative to broadcast, as the high stone content of soils and undulating topography make injection unsuitable. However, it is not clear if the reduced ammonia emissions of the trailing shoe compared to broadcast result in an increase in slurry N uptake by the grass. Therefore, the objective of the experiment presented was to determine slurry NH_4-N recovery in herbage and soil in the year of application as affected by application method and timing (spring versus summer application) using a ^{15}N tracer technique.

Materials and methods The experiment was conducted on permanent pasture at Johnstown Castle, Wexford, Ireland, as part of an agronomic experiment with similar treatments (Lalor & Schulte, 2009). Three treatments were investigated: 1) no slurry applied (N), 2) broadcast application (BC) and 3) trailing shoe application (TS). The NH_4-N fraction of slurry was spiked with highly enriched (99 atom% ^{15}N) ammonium sulphate to give a 2 atom% enrichment (2% of all N atoms were in the form of ^{15}N) and applied to 80 cm by 80 cm micro-plots by watering can at a rate equivalent to 33 tonnes per hectare (~100 kg Total N / ha and 50 kg NH_4-N / ha). The slurry was applied in April (spring application) or June (summer application) 2007 and 2008 with 6 replications. The spring applied micro-plots were harvested and sampled in June, and residual cuts (no additional fertiliser applied) were taken in July and September. Summer applied micro-plots were harvested in July with a residual cut in September. Herbage dry matter (DM) yield >5cm and the total N and ^{15}N concentration in the harvested grass and the soil (top 15 cm) in the 50 by 50 cm square within the micro-plots were determined. The recovery of slurry NH_4-^{15}N in herbage and soil was calculated, and based on that the % of slurry NH_4-^{15}N lost from the system could be determined. Statistical analysis was carried out using PROC MIXED in SAS. The fixed factors were application method, timing and experimental year, including all two- and three-way interactions, and block was included as random factor.

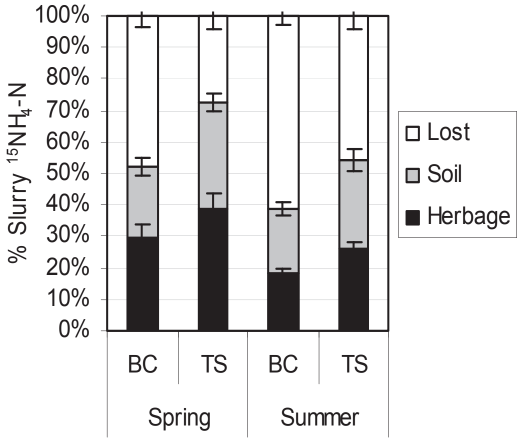

Figure 1 Effect of application method and season on slurry NH_4-^{15}N recovery in herbage (cum) and soil, and on calculated loss (all % of total applied), averaged over two years. Error bars = 2×SE (n=12).

Results Of all the slurry ammonium N applied, at the end of the season on average, 26% was recovered in the soil and 28% in herbage (Fig. 1). The remaining 46% of $^{15}NH_4$-N was lost from the plant-soil system. The main loss pathway for slurry ammonium N is volatilisation, followed by losses through leaching, denitrification and runoff. Additionally, some ^{15}N was probably incorporated into the stubble and root mass, or moved into soil layers below 15 cm, which was not accounted for in this experiment.
Ammonium loss was significantly lower ($p<0.0001$) for TS compared to BC. This resulted in a higher recovery of ammonium in grass and soil (on average by 9 and 10 % points, respectively). The difference between TS and BC was largest in the first cut after application, but remained visible for the residual harvests. The increase in slurry N recovery resulted in a higher yield for TS compared to BC in the first cut after application (on average 4.9 and 4.5 t DM ha^{-1}, respectively) (results not shown).
The ammonium N loss was significantly higher ($p<0.001$) during summer than spring (Fig. 1). This was related to weather conditions after application, as average temperature and radiation tended to be higher, which may have resulted in higher volatilisation (Dowling *et al.* 2008).

Conclusions ^{15}N labelling of slurry proved to be a good tool for plot scale quantifications of N recoveries and losses after application of slurry. The slurry NH_4-^{15}N recovery was significantly higher for trailing shoe compared to broadcast applied slurry. Additionally, NH_4-^{15}N recovery from spring applied slurry was higher than for summer applied slurry. N efficiency in livestock grassland systems can be increased by changing spreading timing to spring and/or spreading method to trailing shoe.

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