Research Stimulus Fund

Final Report

An Evaluation of Strategies to Control Ammonia Emissions from the Land -spreading of Cattle Slurry and Cattle Wintering Facilities

DAFM Project Ref No: RSF 05 211
Start date: 1st November 2005
End date: 30th September 2009

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Other Principle Collaborating Researchers: Tom Curran (UCD), Deirdre O’Connor (UCD), Heather Scully (Teagasc Grange)

Please tick below the appropriate area on the research continuum where you feel this project fits

BASIC/FUNDMENTAL  APPLIED/PRE COMMERCIAL

x

Key words: (max 4)
Ammonia, landspreading, housing, mitigation
1. **Rationale for Undertaking the Research**

Irish agriculture faces considerable challenges in reducing N inputs both in terms of financial sustainability and complying with future emissions targets. The loss of N via ammonia volatilisation represents a challenge both in terms of atmospheric pollution and a loss of resource for the farmer. Under the terms of the National Emissions Ceilings Directive (2001) ammonia (NH3) emissions are limited to 116,000 tonnes by 2010; with further, more stringent, reductions currently under discussion. Agriculture comprises 98% of national ammonia emissions, with cattle accounting for 80% of this total. In terms of agricultural practices, the land spreading of slurry and animal housing comprise 47% and 34% of total emissions, respectively; whilst the remainder is split between manure storage and animal deposition. In terms of atmospheric pollution, ammonia is both a local and trans-boundary pollutant, and also indirectly contributes to greenhouse gas emissions. Ultimately, however, these emissions represent a considerable loss of N to the farmer. Indeed, the economic cost associated N loss via volatilization is c. €60 million. As a result, there is an urgent need to develop abatement strategies to reduce these losses.

2. **Research Approach**

**Sub-project 1: Landspreading:** Although only four landspreading experiments were envisaged in the proposal, eight landspreading experiments were carried out between July 2006 to August 2008 with slurry applied to grassland on a loamy soil using either splashplate or trailing shoe application methods. On all plots, application rates were 33 m$^3$ per hectare. All slurry used for application came from the slatted beef unit at Teagasc Environmental Research Centre, Johnstown Castle, was agitated in the shed 1-3 days prior to application and spread using the same purpose built tanker (Abbey Machinery Ltd, Nenagh Co. Tipperary). The tanker had a capacity of 7 m$^3$ and had a valve which allowed slurry to be circulated inside the tank. The slurry was forced through the pipes to the 24 applicators. Each applicator had a valve to allow the selection of splashplate or trailing shoe application. In order to accurately assess the effect of timing and spreading technique on ammonia emissions, measurements were performed using the flux-gradient technique. This method measured ammonia emissions at various heights (from 0.1 to 2.2m) above the ground, with the sum of the all heights representing the emissions for an area of ground (dependent on the mast height and windspeed). Thus it provided a non-invasive technique and provided an integrated measurement over a large area (100m$^2$). The masts contained passive flux samplers which were coated with acid to trap the ammonia. This trap was subsequently washed and the ammonium content analysed. Experimental data was used to parameterize a statistical model.

**Sub-project 2: Housing Systems:** A comparative assessment of emissions from both slatted sheds and OWPs was undertaken using of direct measurements from acid traps placed at 1m intervals on each side and roof of the building. In addition, emissions plumes arising from housing sources were simulated using atmospheric dispersion models, which simulate the ammonia plume emitted from the housing system. This plume modelling was undertaken as direct emissions measurements from open outwintering pads and lagoons were impractical. This is one of the few studies to compare estimates of emissions from both dispersion modelling and direct measurement from houses.

**Subproject 3: Pollution swapping and cost benefit:** Originally the project foresaw assessing total N losses using the RAINS model. We decided to modify this and use a more complex biogeochemical model (DNDC) to evaluate the impact of ammonia mitigation measures on other reactive N emissions (N$_2$O and leached N). In order to generate a cost-benefit, the total amount of N saved by the mitigation measure was calculated and additional costs (inputs, machinery purchase, labour etc.) subtracted. The mitigation measures evaluated were timing of application, method of application (trailing shoe and injection) and dietary manipulation (reduced crude protein).
3. Research Achievements

**Timing can reduce emissions to the same extent as changing application technique:** On average, 54% of total ammonical nitrogen (TAN) was lost when slurry was applied by splashplate. However, there was significant variation in emissions depending on the prevailing weather conditions for the first four hours after application, with up to 78% of TAN lost on hot, dry days. However, if application was targeted for cooler periods, particularly during spring, emissions were reduced by over 30%.

- **Night application lowers ammonia emissions.** Dusk application during summer halved emissions with only 24% TAN lost.

- **Trailing shoe delivers consistently lower emissions across all climatic conditions:** The adoption of trailing shoe technology reduced ammonia emissions by an average of 36%. In addition the range of ammonia emissions across weather conditions was more consistent. However, under low emission conditions, there was no significant difference between application technique.

- **Housing emissions are lower than in national inventories:** Ammonia emissions from slatted sheds were 8 gNH$_3$-N LU$^{-1}$ day$^{-1}$. This value is considerably lower than the values (38 gNH$_3$-N LU$^{-1}$ day$^{-1}$) used by the EPA in the national ammonia inventories and as such, indicating a substantial overestimation of cattle housing emissions within the inventory.

- **Out-wintering pads increase ammonia losses.** Out-wintering pad (OWP) emissions were 62 gNH$_3$-N LU$^{-1}$ day$^{-1}$ with periods of higher emissions occurring during dry periods. Emissions were substantially reduced (90%) if pads were regularly cleaned. However, OWP’s are in general, not an effective ammonia abatement technique.

- **Spring spreading reduces total N losses compared to other periods.** From model outputs, During March, using splashplate application reduced total reactive N (ammonia + nitrous oxide+leached N), with 48 kg N ha$^{-1}$ lost compared to 58 and 54 kg N ha$^{-1}$ for June and September respectively. The majority of this loss was via volatilisation (82.5%). If N is priced at 0.80 euro per kg, this is a saving of 8 euro per hectare.

- **Application technique alters the balance of emissions.** The largest N saving was associated with moving to injection or trailing shoe in spring, with a 37% decrease in N loss. All of this was associated with ammonia reduction. Under both these techniques, nitrous oxide increased by 32% (trailing shoe) and 96% (injection) while leached N increased 50% (trailing shoe) and 300% (injection). Indeed, under injection, 83% of N loss was via leaching. Although there were N saving associated with these techniques, the associated cost meant a 0.42 euro loss per hectare for trailing shoe and 0.57 euro loss for injection.

4. Impact of the Research

This research demonstrates the effectiveness of both changing application technique and timing. In particular, it demonstrates that N losses to the atmosphere can be reduced without any outlay in terms of new machinery simply by targeting application either early in the season or be evening application. This will increase the N-fertiliser efficiency of slurry (demonstrated in RMIS 5512).

Statistical models generated in this study will provide a starting point for the construction of an Application Timing Management System for Ireland. This would allow farmers to reduce emissions without the requirement to adopt more expensive machinery. This research demonstrates the
effectiveness of altered timing and application technique on ammonia emissions abatement. This will enable stakeholders to make informed decisions as to which strategy to adopt in order to reduce N losses to the atmosphere.

Farmers:
Concerted efforts have been made by Teagasc over the past 4 years using this and associated studies to impress on farmers the loss of N resource if slurry is applied injudiciously. The latest fertiliser use survey has shown a 50% shift in slurry application to earlier in the year.

5. Exploitation of the Research

There was no commercial exploitation associated with this project.

6. Summary of Research Outputs

(a) Intellectual Property applications/licences/patents
1. None
2.
(b) Innovations adopted by industry
1. Abbey Machinery developed, in association with us an experimental slurry tanker that incorporated splashplate and trailing shoe technology
2.
(c) Number of companies in receipt of information
None
(d) Outcomes with economic potential
1. The research clearly shows the economic benefit of early slurry spreading and evening spreading.
2.
(e) Outcomes with national/policy/social/environmental potential
1. The research has quantified a) the mitigation potential of trailing shoe application and b) targeted timing
2. The research has shown that ammonia emissions from housing in national inventories are overestimated. Both these finding will help meet future Emissions Ceiling Directive targets without impeding production.
(f) Peer-reviewed publications, International Journal/Book chapters.
2. Lalor, S., Lanigan, G. (2010). The potential of application timing management to reduce ammonia emissions following cattle slurry application. RAMIRAN 14, 115-119
(g) Scientific abstracts or articles including those presented at conferences

(h) National Report

(i) Popular non-scientific publications
2.

(j) Workshops/seminars/ open days at which results were presented (excluding those in (g))
1. Environ 2008 Dundalk IT Feb 1-3

7. Permanent Researchers

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<tr>
<th>Institution Name</th>
<th>Number of Permanent staff contributing to project</th>
<th>Total Time contribution (months)</th>
<th>Average time contribution per permanent staff member</th>
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<td>UCD</td>
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Total

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Total
9. **Postgraduate Research**

Total Number of PhD theses: 1


10. **Project Expenditure**

Total expenditure of the project: €285128.94

Total Award by RSF: €426839

Other sources of funding (specify): €0

Breakdown of Total Expenditure

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11. **Future Strategies**

This research has been followed on with studies into a) greenhouse gas emissions from land-spreading, b) methane emissions from cattle housing and c) greenhouse gas emissions from outdoor slurry stores. Based on the statistical model developed as part of this project, we are developing a decision-support system for ammonia emissions. This is being fed into our Carbon Calculator.

12. **Industry Collaboration**

We collaborated the Abbey Machinery Ltd. in association with RSF 05 212 to develop an experimental combined splashplate and trailing shoe slurry tanker.