Research Stimulus Fund

Final Report

Efficient and Reliable Utilisation of Nutrients in Animal Manures

DAFF Project Ref No: RSF 05 208
Start date: 01/01/2006
End date: 31/03/2010 (extended from 31/12/2009)

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Dr. Richie Hackett, Teagasc, Oak Park
Reamonn Fealy, Teagasc Rural Economy Research Centre

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

BASIC/FUNDMENTAL  APPLIED/PRE COMMERCIAL

☑  ☑  ☑  ☑

Key words: (max 4)
Manure; Nutrients; Grassland; Tillage
1. **Rationale for Undertaking the Research**

The Nitrates Directive regulations impose limits to nitrogen (N) and phosphorus (P) inputs onto livestock and tillage farms. This is having a large impact on both cattle/dairy farms and pig farms.

Cattle and dairy farming systems are required to make more efficient use of nutrients. International experience suggests that significant gains in nutrient efficiency can be made by increasing the utilisation of N in slurry. Data from Teagasc, Johnstown Castle, suggested Nitrogen Fertilizer Replacement Value (NFRV) from slurries as low as 5% under existing practices, whereas international literature suggests that there is scope to raise NFRV to 40-80%. Despite the relatively low utilisation in practice, the Nitrates regulations set an NFRV target of 40%, presenting a considerable challenge for the grassland sector.

In addition, the ceiling to nutrient inputs imposed under the Nitrates Directives made it difficult for many livestock farmers to continue to accept pig slurry as a fertilizer onto their farm. As a result, the potential for the traditional practice of spreading slurry on grasslands has been reduced significantly. Returning pig slurry to arable land allows a more closed nutrient cycle to operate, since cereal grains constitute a significant proportion of the diet of pigs. However, this creates a major logistic challenge where arable land and pig farms are not closely located.

2. **Research Approach**

This research project had four objectives:

1. To identify strategies and methods for application of cattle slurry to grassland that maximise the NFRV and reduce the variability associated with predicting the nutrient utilisation in the year of application
2. To quantify the residual effect of cattle slurry applications to grassland on the NFRV in subsequent years
3. To quantify the fertiliser replacement value of pig slurry applied to cereal crops
4. To investigate the transport distance implications at a national scale of transporting pig slurry to suitable tillage areas

Four separate experimental studies were conducted to address the four project objectives.

A field study was carried out over 3 sites and 3 years to compare the effects of application method (splashplate and trailing shoe) and application timing (April and June) on the NFRV of cattle slurry in grassland. This experiment was carried out on field plots using farm-scale slurry application machinery.

A similar study was also conducted to examine the long-term effects of the residual N release from cattle slurry in the years following application. This experiment was carried out on small scale plots and soil cores, and included $^{15}$N stable isotope technology to trace the pathways of slurry-N in the soil and plant system over time.
The NFRV of pig manure applied to cereal crops was assessed in a total of 18 field experiments in five separate locations over four years. The field trials compared the grain yield and N uptake in spring barley between chemical N fertilizer and pig manure. Pig manure was applied and incorporated rapidly into the seedbed by ploughing. Yield response curves for fertilizer N with and without pig manure were used to calculate the NFRV of the pig manure.

The fourth part of the project was a desk study of the transport distances required to find arable spreadlands for pig manure. Datasets of land use, road networks and pig farm locations were analysed to calculate the average travel distance required in order for pig manure to be applied to arable land. The analysis facilitated regional comparisons of the average travel distances required.

3. Research Achievements

The experiments with cattle slurry application on grassland show that the NFRV in the year of application was affected by application method and timing. Cattle slurry applied with splashplate had an NFRV of 21% in April and 12% in June. Application using trailing shoe increased the NFRV to 30% in April and 22% in June. Changing application timing from summer to spring with existing splashplate machinery is the most cost effective strategy for improving NFRV.

Approximately 4% of the total slurry N applied was recovered in the second year after application. For repeated applications over a number of years, models indicate that the maximum cumulative residual recovery would be 12-14% of the annual slurry N application rate. It would take approximately 10 years of repeated slurry applications for the residual N release to reach this maximum level.

The NFRV target of 40% set in the Nitrates regulations was only achieved when the residual N release was included, and when best practice strategy of trailing shoe application in April was adopted. Spring application of slurry is often restricted by soil trafficability, particularly on poorly drained soils. The trailing shoe application method can provide more flexibility for spring application as grass contamination is reduced compared to splashplate.

The NFRV of pig manure on cereal crops was 50% on average. This is in agreement with the target in the nitrates regulations. However, the NFRV of 50% is only achievable under best practice whereby the manure is incorporated into the soil immediately (< 2 hours) after application. The NFRV of 50% refers to the actual total N content of the pig manure being applied. This can differ from the total N content assumed in the Nitrates regulations. There can be considerable variation in the total N content of all manure types.

In a best case scenario where all arable spreadland was available to receive pig manure, the national per-parcel manure transport distances from pig farms to arable farms was 22 km. This transport distance was increased when the willingness of farmers to use pig manure, and the variation in the P requirements of soils and crops was taken into account. The transport distance varied considerably between regions, and results confirmed expectations concerning
counties in the south east and east of Ireland with the average distance to parcel by county well below the modelled national average of 22 km, while counties in the north and west had average travel distances that were far higher.

4. Impact of the Research

An extensive programme of dissemination was undertaken within this project, with a total of over 100 outputs to the scientific and farming community. Publications to date include: 5 scientific papers; over 20 contributions to international and national conferences; over 30 popular publications; and over 70 presentations to farmers and advisors at various open days, seminars, demonstrations, workshops and radio. The dissemination to farmers was strongly channelled through the Teagasc Advisory service, and the application of this research will help farmers to exploit their organic fertilizer resources in order to improve organic fertilizer utilisation within nutrient management for grassland and cereal crops. The results of the project will be incorporated into future nutrient advice publications of Teagasc.

5. Exploitation of the Research

The outcomes of this research provide valuable information for farmers for improving the fertilizer cost savings that can be made through more efficient manure management in grassland and cereal crops. The research has also provided farmers with more reliable ‘best management’ protocols for ensuring that NFRV of manures applied to grassland and tillage is maximised in a cost effective way. The research also provides a template for spatial analysis of manure sources relative to spreadland availability.

The outcomes of the research are being exploited in a number of ways. The data generated regarding NFRV of cattle and pig manures in the year of application and in subsequent years has been central to the changes in manure NFRV values that have occurred in the review of the Nitrates Action Programme. Additionally, the spatial analysis of spreadland availability also informed the debate on the transitional arrangements for the pig, poultry and mushroom sectors.

6. Summary of Research Outputs

(a) Intellectual Property applications/licences/patents
   None

(b) Innovations adopted by industry
   1. Some uptake of trailing shoe technology at farm level
   2. Increased awareness of fertilizer value and potential economic savings of using manure nutrients more effectively

(c) Number of companies in receipt of information

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1. A large number of Slurry machinery retailers and manufacturers were in receipt of information through the variety of Open Days and Demonstrations that were organised within the project

(d) Outcomes with economic potential
1. Fertilizer savings due to improved reliability of NFRV prediction
2. Cost implications of slurry transportation

(e) Outcomes with national/policy/social/environmental potential
1. Input to Nitrates Action Plan Review
2. Input into review on ammonia emissions abatement policies

(f) Peer-reviewed publications, International Journal/Book chapters.

(g) Selected Scientific abstracts or articles including those presented at conferences

A Project Conference was held in Teagasc, Johnstown Castle, Wexford, on 26 November 2009. Approximately 60 people attended, and represented policy, scientific, extension, and farming stakeholders. A proceeding booklet was published for the Conference. The conference included papers from each of the 4 sub-projects, and also had presentations from each of the Steering Committee members.

Scientific abstracts or articles from this and other conferences included:

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(h) National Report
Contributions to:
Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010. Teagasc, 115 pp.

(i) Selected Popular non-scientific publications

(j) Selected Workshops/seminars/open days at which results were presented
4. EPMAN and TFRN Meetings in Milan (Nov 2008), Dublin (Sept 2009) and Amsterdam (Nov 2009).
8. Numerous other presentations (> 70 in total) to Teagasc advisors and Agricultural consultants, Farm Walks and Open Days, along with a number of radio and TV interviews.
7. **Permanent Researchers**

<table>
<thead>
<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>
</tr>
</thead>
<tbody>
<tr>
<td>Teagasc, Johnstown Castle</td>
<td>8</td>
<td>50.7</td>
<td>6.3</td>
</tr>
<tr>
<td>Teagasc, Oak Park</td>
<td>5</td>
<td>28.5</td>
<td>5.7</td>
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<td>Teagasc, Rural Economy Research Centre</td>
<td>1</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>University College Dublin</td>
<td>1</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>89.9</strong></td>
<td><strong>5.6</strong></td>
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8. **Researchers Funded by RSF**

<table>
<thead>
<tr>
<th>Type of Researcher</th>
<th>Number</th>
<th>Total Time contribution (months)</th>
<th>Average time contribution</th>
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<tbody>
<tr>
<td>Post Doctorates (2 Researchers)</td>
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<td>32.4</td>
<td>16.2</td>
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<tr>
<td>Contract Researchers (1 technologist)</td>
<td>1</td>
<td>26.8</td>
<td>26.8</td>
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<tr>
<td>PhD postgraduates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Masters postgraduates</td>
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<td></td>
<td></td>
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<tr>
<td>Temporary researcher</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other (4 Technicians + 2 student placements)</td>
<td>6</td>
<td>30.5</td>
<td>5.1</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>89.7</strong></td>
<td><strong>10.0</strong></td>
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9. **Postgraduate Research**

Total Number of PhD theses: None

Total Number of Masters theses: None
10. **Project Expenditure**

Total expenditure of the project: €598,162

Total Award by RSF: €599,336

**Breakdown of Total Expenditure**

<table>
<thead>
<tr>
<th>Category</th>
<th>Teagasc Johnstown Castle</th>
<th>Teagasc Oak Park</th>
<th>UCD</th>
<th>Teagasc RERC</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Contract staff</td>
<td>€81,887</td>
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<td></td>
<td></td>
<td>€81,887</td>
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<tr>
<td>Temporary staff</td>
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<tr>
<td>Post doctorates</td>
<td>€153,302</td>
<td>€126,288</td>
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<td>€279,590</td>
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<td>Post graduates</td>
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<tr>
<td>Consumables</td>
<td>€60,940</td>
<td>€19,217</td>
<td>€20,465</td>
<td>€10,000</td>
<td>€110,621</td>
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<tr>
<td>Travel and subsistence</td>
<td>€45,960</td>
<td>€5,599</td>
<td>€1,788</td>
<td>€1,016</td>
<td>€54,363</td>
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<td>Sub total</td>
<td>€342,089</td>
<td>€151,104</td>
<td>€22,252</td>
<td>€11,016</td>
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<td>Durable equipment</td>
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<td></td>
<td>€19,056</td>
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<tr>
<td>Other</td>
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<td>Overheads</td>
<td>€34,209</td>
<td>€15,110</td>
<td>€2,225</td>
<td>€1,101</td>
<td>€52,645</td>
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<td>Total</td>
<td>€395,354</td>
<td>€166,214</td>
<td>€24,477</td>
<td>€12,117</td>
<td>€598,162</td>
</tr>
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</table>

11. **Future Strategies**

This research has also provided information towards determining future manure management policy regarding ammonia emission reduction strategies for slurry application. Notwithstanding potential market fluctuations in fertilizer and machinery prices, this research shows that existing splashplate machinery, when managed in a way that optimises weather conditions at the timing of application, is the most cost effective means of improving NFRV through reduced ammonia losses.

The outcomes of this research will also be used to feed into further research work. For example, the data the NFRV experiments on grassland are being used to further develop weather-based predictive models of NFRV and ammonia emissions following cattle slurry application.
12. Industry Collaboration

Collaboration with many aspects of the industry was facilitated within this project. Through the wide range of popular and technical dissemination outputs, there were regular contacts with the local and national agricultural media bodies, including radio and the press. The dissemination activities also included involvement with a number of Industry Associations such as The Fertilizer Association of Ireland, The Irish Tillage and Land Use Society (ITLUS), and the Farmer Representative Bodies. The demonstration, development and research of application method technologies also facilitated collaboration with machinery retailers and manufacturers at a range of Open Day, Demonstration and Farm walk events.